

Tender No: BMRCL/Phase-2/Reach-1B Extn./Via/2026/150



BANGALORE METRO RAIL PROJECT, PHASE-2

Name of the Work: “Extension of Metro line by length of 482.80 m beyond Whitefield Metro Station in Reach-1B for Bangalore Metro Rail Project, Phase-2.”

**TECHNICAL DOCUMENT
VOLUME -2**

June-2026

Section - H
EMPLOYER'S REQUIREMENTS
FOR

Name of Work: "Extension of Metro line by length of 482.80 m beyond Whitefield Metro Station in Reach-1B for Bangalore Metro Rail Project, Phase-2."

Table of Contents

1. OBJECTIVE.....	3
2. RELEVANT DOCUMENTS	3
3. GENERAL	3
4. OBTAINING CLEARANCES/CERTIFICATES FROM AUTHORITIES	6
5. INTER COMMUNICATION FACILITIES	6
6. SITE INFORMATION	6
7. RESTRICTION IN WORKING.....	6
8. GENERAL CLIMATIC CONDITIONS.....	7
9. WORK CONTENT- (Extensions for Viaduct)	7
10. TEMPORARY WORKS	10
11. DRAWINGS.....	11
12. TRAFFIC MANAGEMENT	17
13. LIGHTING AND FIRE PREVENTION:	18
14. UTILITIES.....	18
15. Barricading of Site and Work Areas	19
16. INTERFACE WORKS.....	19
17. RESPONSIBILITIES OF CONTRACTOR.....	19
18. ASSOCIATED WORKS DEEMED INCLUDED IN ITEM RATES OF PERMANENT WORKS.....	22
19. PENALTY FOR NON-COMPLIANCE	22
Annexure-1.....	24
1. PROGRAMME REQUIREMENTS	24
2. MONTHLY PROGRESS REPORTS.....	32
Annexure-2.....	36
1. INTRODUCTION.....	36
2. MEASUREMENT OF WORKS.....	36
Annexure-3.....	38
QUALITY ASSURANCE	38
Annexure-4.....	41
Annexure – 5.....	44
Annexure-6.....	47
Annexure-7.....	50
Annexure-8.....	51
Annexure-9.....	52

EMPLOYER'S REQUIREMENTS - SCOPE OF WORK

1. OBJECTIVE

The objective of the contract is the construction, testing and commissioning of the permanent works, construction and removal of the Temporary Works and the rectification of defects appearing in Permanent Works by the Contractor in the manner stipulated by the Contract. In full recognition of this objective, and with full acceptance of the obligations, liabilities and risks which may be involved, the Contractor shall undertake the execution of the Works. The general and specific requirements of the Employer are being detailed out in this document for understanding of the bidders and for mandatory compliance by the successful bidder/contractor. The Employer's requirements have been divided into different sections/sub-heads for convenience only. They do not restrict any cross-references. The Contractor shall take into account inter-relations between various parts of works/trades. No claim shall be entertained on account of compartmental interpretations.

2. RELEVANT DOCUMENTS

The Engineer shall issue Good for Construction (GFC) drawings to Contractor for the execution of works in accordance with the agreed terms and conditions of the Contract Agreement.

The following Documents shall be referred in conjunction with each other by the Contractor for construction work as these are mutually complimentary to each other:

- Good for Construction Drawings issued by the Engineer
- Employer's Requirements as part of Contract
- Technical Specifications and explanatory notes to the BOQ, as part of Contract
- Bill of Quantities as part of Contract
- Indian and International Standards referenced therein.
- The schedules and any other documents forming part of the Contract.

The Contractor shall always seek advice from the Engineer in the event of conflicts among above cited documents. In case of conflict, Engineer's decision shall be final and binding.

3. GENERAL

- i. The project site is located in Bengaluru City. The location of the work and the General site particulars are shown in the tender Drawings enclosed in the bid Documents.
- ii. Before carrying out the work at site, necessary permissions from various local agencies/ authorities / road authorities such as BBMP, BDA, BWSSB, NH, PWD, GAIL and GAIL gas, Traffic Police etc., shall be required to be obtained by the contractor. The Employer shall assist only by way of issue of necessary support letters.
- iii. Any public utility services affected during the execution of works, must be temporarily restored by the contractor concerned. Such works shall be deemed to be part of the contract.

- iv. The contractor shall take all precautions for safeguarding the environment during the course of the construction of the works. He shall abide by all laws, rules and regulations in force governing pollution and environmental protection that are applicable in the area where the works are situated. The contractor must take all necessary steps to fix specially dust nuisance during the construction of the works.
- v. The levels, measurements and other information concerned to the existing site as shown on the drawings are believed to be correct, but the contractor shall verify and also examine the nature of the ground as no claim or allowance whatsoever will be entertained on account of any error or omission in the levels or strata turning out different during execution from what is shown on the drawings.
- vi. The present position of preliminary works of the section is as below,
 - a. The existing road of GBA/BDA/NH can be used for construction of viaduct, etc.
 - b. Utilities pertaining to GBA, BWSSB, GAIL, BESCO, BSNL and other private agencies (OFC) have been identified and already shifted by the employer.
 - c. The trees along the alignment have been identified and already removed/translocated. However, any shifting of utility will be the responsibility of the contractor and payment will be made under the contract.
- vii. Further preliminary works such as site clearance, barricading, trail trenching for identification of utilities if any etc., wherever required shall be taken up simultaneously along with mobilization activities.
- viii. The contractor shall at all-time carryout the work on highway/road/service road in a manner creating least interruption to the flow of traffic. The contractor shall take prior approval of the Engineer and Traffic Police for diversion of traffic during course of construction.
- ix. All temporary traffic diversion works which will be required for the smooth flow of running traffic in order to carry out the works without any interruption including all safety precautions, signage, barricading, emergency lighting, traffic marshals, look-out men/watchmen etc.; The permanent traffic diversions will be carried out in consultation with traffic police. Contractor has to provide traffic diversion proposals, traffic marshals, cones, humps, traffic diversion boards etc., as desired by Traffic Police.
- x. Works to be performed shall also include all general works, including Road widening and allied works of any kind necessary for the due and satisfactory construction, completion and maintenance of the works to the intent and meaning of the drawings adopted and technical specifications, to best Engineering standards and orders that may be issued by the Engineer from time to time.
- xi. The road works and allied works to be carried out in co-ordination with BBMP as per MoRTH, specifications. On award of work, the contractor has to start the road work along and complete the same.
- xii. Road widening works wherever required; widening of road is as in the scope of contract. Further, if diversions of roads need any upgradation as desired by the Engineer, Contractor shall carry out the works and will be paid under the relevant BOQ. Road widening and drainage work to be completed before the commencement of viaduct/station work at any particular location.

- xiii. Restoration of Road and allied works immediately after completion of work up to road level or as per instructions of Engineer.
- xiv. Tree cutting and (or) transplantation along the alignment expected to infringe with the structure work. Permission from local government authorities concerned for cutting/transplantation will be arranged by BMRCL.
- xv. Demolition of RCC framed structures, Brick masonry buildings including basement etc. as existing at site without damaging adjacent structures. Any leftover works for demolition are to be undertaken by the Contractor the payment for the work will be made out as per BOQ.
- xvi. Debris and other disposable construction materials shall be collected and transported for disposal at GBA identified C&D waste management facility as per 'Construction & Demolition Waste Management Rules, 2016 and as per latest policy of GBA/GOK .
The said rules, guidelines and dust mitigation measures are available on the CPCB website www.cpcb.nic.in.
However, the utilised excavated earth shall be disposed by the Contractor at his own cost in the dumping yard approved by the concerned authorities. Nothing extra shall be paid on this account.
- xvii. Ready Mix Concrete (RMC) may be used for Concreting duly approved by Engineer as per the directions of the Engineer.
- xviii. The wheels of the construction equipments and vehicles leaving site shall be cleaned with Jet Wash to avoid spillage of earth/mud on public roads. The Contractor shall ensure cleanliness of the roads and footpaths by deploying man power for the same. The Contractor shall ensure proper cleaning and washing of roads and footpaths at all the times throughout the entire stretch throughout the contract period. Nothing extra shall be payable.
- xix. The construction programme and project monitoring is to be furnished by the contractor as mentioned in General Conditions of Contract. The detailed programme shall be in the form of a quantified bar chart or MSP/Primavera activities throughout the project period.
- xx. Measures to minimize water, air and noise pollution;
- xxi. All aspects of quality assurance, including testing of materials and other components of the work, as specified and as directed;
- xxii. Geotechnical investigation work shall be as directed by the Engineer;
- xxiii. Clearing of site and handing over of all the permanent Works, as specified or as directed by the engineer;
- xxiv. Repair/Rectification of Defects in the completed Work if any during the defect liability period as directed;
- xxv. Submission of completion (i.e. 'As-Built') drawings and other related documents as specified;
- xxvi. The contractor shall not display any name-board for the works without the written permission of the Engineer.
- xxvii. No labour camp shall be allowed at work site or any unauthorized place.

4. OBTAINING CLEARANCES/CERTIFICATES FROM AUTHORITIES

The contractor shall arrange well in advance stage wise as may be required, submission of all the required documents and drawings for approval from other authorities and installation of the works and their inspection and obtain approval/completion certificates with respect to his work as required for use and connection of the utilities and occupation from the Statutory Authorities. The Contractor shall obtain and deliver to the Engineer, on completion of the works, the final Inspection Report and approval from the Authorities.

5. INTER COMMUNICATION FACILITIES

Telephone and fax services are available at Bengaluru. Should the Contractor wish to use Radio communication on the site, employer will arrange for the allocation of the radio frequency by the concerned authority.

6. SITE INFORMATION

The project site is located in Bengaluru City. Bengaluru is well connected to other parts of the country by Road, Rail and Air. It has an International Airport. The location of the work and the General site particulars are shown in the General Arrangement Drawings enclosed in the bid documents.

7. RESTRICTION IN WORKING

It has to be noted by the Bidder that,

- a. Few of the construction works have to be carried out in congested roads/streets of Bengaluru city where there are buildings adjacent to the road and road traffic may be heavy.
- b. There will be restrictions to movement of heavy construction machineries during day time. In such cases contractor shall make use of night times with proper planning for mobilization of resources as required.
- c. One way roads are existing at certain stretch of the alignment where traffic movement is prohibited in both the direction.
- d. Generally, at least two lanes of traffic in both directions has to be kept while the works are on, including foundation works.
- e. The construction of structures will have to be planned in such a manner that they do not obstruct or interfere with the existing roads, Railways and other utilities. Since the entire Alignment is coming in City road, the movement of Heavy Vehicles is expected, wherever the stations/approaches to the Depots/Viaduct works are at the middle of the road / across the roads, erection of pre-cast members may have to be planned in such a way that the erection shall be done from one end with Back feeding/as approved by Engineer. Unless the competent authorities permit to execute such works using cranes and restricting the movement of the Vehicles, the same may be planned to carry out during night times during permitted working hours. Also, while working in the night hours, noise pollution should be kept to an acceptable level. The bidder should take all these facts into account while quoting rates and devise his methodology of working accordingly.
- f. Where work is required to be carried out at locations adjacent to such roads, utilities, structures, monuments, religious structures, etc., suitable safety and protection

arrangements shall be ensured. Nothing extra shall be payable on these accounts. It should also be ensured that no damage is caused to any such elements. In case if any damage occurs, Engineer/ Employer shall be indemnified against such damage at no extra cost.

8. GENERAL CLIMATIC CONDITIONS

Bengaluru is located in meridians of 12° N latitude and 77°3' E Longitude, spread over an area of 531 sqkm, located at an altitude of 900m. Bengaluru boasts of delightful weather around the year registering maximum temperature of 34° centigrade in summer and minimum temperature of 14° centigrade in winter. Bengaluru receives both the Southwest and Northeast Monsoons, getting an annual average rainfall of 760 mm, generally during the months of May to September/October. Bengaluru falls in Seismic Zone II.

9. WORK CONTENT- (Extensions for Viaduct)

9.1 Brief Scope

This bid is for construction of Elevated Viaduct Structures comprising Pile Foundation/Open Foundation/Raft Foundation, cast in-situ Pier, Pier arm & Portal beam, Precast Portal Beams-Girders, PSC I – Girder, PSC T– Girder, Composite girder, Deck Slab, parapet, handrail and Road Widening including Drains & Allied Works, Construction of Service Roads/bus-bays, Foundation Work has to be taken up in presence of GAIL pipe line along the alignment as per Annexure-08.

- a) Works to be performed shall also include all general works preparatory to the construction of Viaduct and works of any kind necessary for the due and satisfactory construction, completion and maintenance of the works to the intent and meaning of the drawings adopted and technical specifications, to best Engineering standards and orders that may be issued by the Engineer from time to time, compliance by the agency with all as per Contract Document.
- b) Supply of all materials, apparatus, plant, equipment, tools, fuel, water, strutting, timbering, transport, offices, stores, workshop, staff, labour and the provision of proper and sufficient protective works, diversion, temporary fencing, lighting and watching required for the safety of the public and protection of works on adjoining land; first-aid equipment, accommodation and sanitation for the staff and workmen, effecting and maintenance of all insurances, the payment of all wages, salaries, provident fund, fees, royalties, duties or the other charges arising out of the erection of works and the regular clearance of rubbish, clearing up, leaving the site perfect and tidy on completion.
- c) The work content in this contract consists of, but not limited to, furnishing all labors, materials, equipments, tools, plants and necessary machinery as required to completely execute all the works relating to Construction of Elevated Viaduct along with utility relocation and diversions if and to the extent required etc.

- d) The work is to be constructed and maintained as per BOQ, Technical Specification, relevant Codes, and specifications of MORTH, CPWD, KPWD, Drawings, best engineering practices and/or as directed by the Engineer.

9.2 The Scope of Civil & Structural Works:

The scope of works shall, inter-alia, include the following but not be limited to:

- a. Site clearance and dismantling of obstructions, etc., before commencement of work as specified or as directed;
The bidder must visit site and acquaint him with the local conditions before quoting. Site clearance which includes dismantling of median, footpath, any temporary structure, small shed etc. All the trees and hoarding/buildings coming in the way of construction of Viaduct shall be cleared by Contractor, cutting of trees / branches or transplantation of trees also may have to be done by the Contractor for which payment will be made under relevant schedule of payment in pricing schedule. BMRCL will make necessary arrangement for clearance as required.
- b. True and proper setting out and layout of the works, bench marks and provision of all necessary labour, instruments and appliances in connection therewith as specified and as directed;
- c. Provision of foundation works for different structures i.e. viaduct/track structure, etc. including piles (1500mm ,1200mm dia, 1000mm dia, 600mm dia, etc.,) and pile caps /open foundations / rafts for columns/ piers/walls (wherever required) up to the minimum founding depths in accordance with the actual soil parameters as obtained from detailed sub-surface exploration as specified or directed. The Construction methodology is required to be approved by BMRCL before carrying out the works.
- d. Provision of RCC piers/cut and cover walls, precast pier caps & precast pier arms /portal pier beams, bearings, as specified or as directed.
- e. Provision of superstructure for viaduct consisting of precast (pre-tensioned) reinforced cement concrete, I-girders, composite girders, parapet & cast-in-situ deck slab works. The cross-section, width and profile of superstructure are shown in the tender drawings.
- f. The girders may be tapering in plan (if and wherever required as per drawings) are to be cast true to the profile as far as possible by suitable formwork system.
- g. Obtaining Approval of Erection scheme for Viaduct.
- h. Provision of Composite Girders for Obligatory or Railway Spans according to IRS codes and specifications, RDSO guidelines, standards and as per railway authority requirements. Girder should be fabricated by RDSO approved vendor in approved factory.
- i. Conducting load test on girders. The cost for such tests is provided in the Bill of Quantities. However, the actual numbers will be advised to the successful bidder on award of contract;

- j. Providing, fabricating and fixing MS members to be used as fixtures supports / hangers etc. for system contractors.
- k. Providing fixing in position holding down bolts/inserts/dowels for all the civil works is inclusive in respective items of work unless specified separately. Contractor shall fix the bolts/inserts supplied by BMRCL/ other interface contractors time to time as required and the rate for such activity is included in item and nothing extra shall be payable.
- l. Grouting of anchor bolts with approved non-shrink compound.
- m. Any other item of work as may be required to be carried out for completing the construction of Elevated viaduct structures as specified in drawings including all necessary interface works with other-interface contractors, etc. in all respects in accordance with the provisions of the Contract and/or to ensure the structural stability and safety during and after construction.
- n. **SPECIAL NOTE: -**

i) 200mm Live GAIL Line

Along the full length of the alignment 200mm GAIL gas line is running live. Contractor has to work in presence of the GAS line. (**Refer Annexure-8**).

ii) Foot Over Bridge (FOB) at BP-505 to BP-506.

One FOB (Foot Over Bridge) of KRDCL will be landing on the foundation of pier no-505 and 506. Therefore, contractor has to work in close co-ordination with KRDCL and their contractor so that hindrance may not be caused to their work. Launching of Railway span across 503 and 504 has also to be planned to keep in mind presence of upcoming FOB of KRDCL for this also contractor has to work in close co-ordination with KRDCL and their contractor.

The Contractor shall treat these works as milestone activities and complete the same on priority with necessary resource deployment and extended working arrangements, if required.

iii) Railway Span at BP-503 to BP-504 (65m Composite Girder span)

The launching scheme and its design, drawing have to be submitted by the contractor using sufficient capacity Cranes duly proofchecked by IIT/IISc and get it approved from Railway as per railway board letter no 2022/7/CE-III/BR/Fabrication dated 29.05.2023 (**Refer Annexure-9**). No extra cost will be paid on this account.

Contractor has to engage specialized third party inspecting agency viz., RDSO, RITES, WRI, CEIL and KRCL, for QAP approval, inspection of fabrication, assembly and for launching of railway span complete (Refer railway board letter no 2022/7/CE-III/BR/Fabrication dated 29.05.2023.) No extra cost will be paid on this account.

"The Contractor shall be responsible for obtaining all necessary approvals, permissions, drawings approval, traffic/power block approval, and clearances from the Railway Department for the erection, installation, and dismantling of temporary and permanent support arrangements, including temporary support I-girders, staging, launching girders, complete launching scheme and appointment of third-party agency for inspection as per railway .

The Contractor shall submit detailed design calculations, drawings, methodology statements, safety measures, and execution procedures to the Railway Authorities through engineer and obtain approval before commencement of the work.

All works shall be executed strictly in accordance with Railway standards, approved drawings, safety regulations, and instructions issued by the Railway Authorities from time to time.

Any delay arising out of non-submission or non-approval by Railway Authorities due to reasons attributable to the Contractor shall be deemed to be included in the Contractor's scope, and no additional cost or time extension shall be payable on this account."

9.3 Structural elements, shape and form

The bidder to note the different structural elements in shape and form, and structural configuration in plain. The structural elements may be skew, tapered, curved etc. The bidder shall include these factors while quoting his rates. All the above are to be covered in the quoted rates and nothing extra shall be payable towards this. The GFC drawings shall be final for this.

9.4 Stability of the elements

During construction, the stability of each element must be ensured until the connections through which the stability is achieved, are fully operative. This might require temporary, supporting, bracing etc. This is contractor's responsibility and no extra payment is to be made.

9.5 Stability of the Structure

The overall stability of the structure must be ensured during each phase of constructions. This might require special provisions. This is also contractor's responsibility and no extra payment will be made.

9.6 Scope of Architectural Works. (Excluded from the scope of the work)

9.7 Scope of Design work (Permanent work)

Design for the permanent work is not under scope of this work, which is "construct only". The necessary details of the same as required by DDC or other designated contractors of system-wide contracts will have to be furnished by the contractor well in time for the subject bid and necessary interfacing and coordination to be done with them as outlined in the Project Wide Interface Document.

10 TEMPORARY WORKS

Traffic barricade with reflective tapes/lights and other necessary traffic signages should be provided wherever required so that safety is ensured during day and night continuously. Temporary traffic diversion for smooth flow of traffic during construction including necessary traffic signs boards, repairs to the diverted route/service lanes, if required, restoration of diverted route to original condition etc. shall be done by contractor at his own cost.

Contractor shall also provide any temporary support for the utilities (charted or uncharted), wherever required, at no extra cost to Employer.

The above listed works are only brief but the actual scope of work shall be as specified in the related document and/or as specified or directed by the Engineer.

10.1 Design for Temporary Works

The Design should cover all the items pertaining to all temporary works, traffic diversion scheme, form work, casting and stacking yard, staging, launching scheme for girders/beams and/or

transportation scheme for various structural elements and materials to be transported to and from site during construction period.

The Contractor shall himself formulate a practical and viable scheme for design/ fabrication of shuttering, casting, curing, testing and launching/erection of girders/beams/ and all other structures. The bidder should, along with the bid, specify the scheme that he proposes to adopt for carrying out all the works including fabrication, transportation, stacking and erection of steel structure and casting, curing, stressing, testing and launching/erection of girders/beams.

The contractor shall formulate the erection scheme, design the staging, including all necessary temporary structure, prepare fabrication drawings in accordance with relevant provision of applicable IRC standards and submit the same to the Engineer for approval with third party certificates. These works will be executed only after the approval has been obtained from Engineer.

11. DRAWINGS

1. The Drawings furnished with the Bid Documents are tender drawings may require change at the time of actual execution of works based on actual site conditions. Drawings furnished with the Bid Documents show the level of works based on available soil investigation data. These may require change at the time of actual execution of works based on actual site conditions.
2. Tender drawings represent Employer's proposal based on Design. Detailed working drawings will be given for construction of work progressively subsequently to the successful bidder.

11.1 GFC Drawings:

11.1.1 Requirement.

The GFC drawings requirement shall be informed in advance by the contractor based on his Three Month Rolling Programme.

11.1.2 Errors, Omissions and Discrepancies in Specifications and Drawings:

- a. It shall be the responsibility of the Contractor to promptly bring to the notice of Engineer any error, omission fault, defects or discrepancy in the contract documents, specifications and drawings for the work which are discovered while reviewing the contract documents or in the process of execution of the works and obtain his orders thereon. In case any feature of the work is not fully described and set forth in the drawings and specifications, the Contractor shall forthwith apply to the Engineer for further instructions, drawings or specifications. Responsibility of the Correctness of the details in the Good for Construction drawings issued by BMRCL lies with the contractor. Any omissions, errors, discrepancies in the drawing shall be brought to the notice of the Engineer immediately for issue of revised drawings.
- b. Only stated dimensions are to be taken and not those obtained from scaling drawings.
- c. In case of errors, omissions, faults, defects and/or disagreement on the drawings or between the drawings and specifications the following principles shall be followed.

- i. As between the written description or written dimensions on the drawing and the corresponding one in the specifications, the former shall apply.
- ii. As between the written description of the item in Bill of Quantities and the detailed description in the specification of the same item, the former shall prevail.
- iii. The drawings on a large scale shall take precedence over those on a smaller scale; and
- iv. Drawings approved as construction drawings from time to time shall supersede corresponding drawings previously approved.

The Contractor shall follow the instructions of the Engineer on this matter.

11.2 Meaning and intent of Specifications and Drawings:

If any ambiguity arises as to the meaning and intent of any portion of the specifications and drawing or as to execution or quality of any work or material, or as to the measurement of the works, the decision of the Engineer thereon shall be final subject to the appeal (within 7 days of such decision being intimated to the Contractor) to Engineer/Employer who shall have the power to correct any errors, omissions, or discrepancies in the specifications, drawings, classifications of works or materials and whose decision in the matter in dispute or doubt shall be final and conclusive.

11.3 Responsibility for Specifications, Design and Drawings

a) Specifications

MORTH / CPWD, KPWD Specifications / other Specifications / Codes viz. IS, IRS, IRC, DSR etc. shall be maintained by the contractor at site throughout the project period for reference. Standards ensuring guarantee to a level of quality or performance equivalent or superior to those indicated will also be accepted. Reference to trademarks or other specific designations that is necessary to explain the nature of the products required means that any other product of equal or superior quality or performance is also acceptable, subject to prior approval of the Engineer to be obtained in writing for adopting the new standards which are not provided in the contract.

b) Drawings for Permanent Works:

- i. Preliminary Drawings as listed showing general dimensions & details elaborating the scope of work (not based on detailed design) are supplied along with the bid documents. These drawings are broadly indicative of the work to be carried out. These drawings are not "Construction Drawings" and details indicated therein are for general guidance only and shall be modified by the Engineer, to incorporate additional details as per design, and as described in the Specifications and the Bill of Quantities.
- ii. The Permanent Work shall be carried out in accordance with the "Good for Construction" (GFC) drawings as would be issued to the Contractor by the Engineer duly signed and stamped. The Contractor shall not take cognizance of any drawings, designs, specifications, etc. not bearing Engineer's signature and stamp. Similarly, the Contractor shall not take cognizance of instructions given by any other Authority except the instructions given by the Engineer/Employer in writing. Construction drawings shall be supplied progressively

depending on the progress of work by the contractor during execution of work well in time for each activity.

- iii. The contractor cannot claim as a matter of right that all Good for Construction drawings (GFC drawing) shall be issued soon after award of contract. GFCD/Advance copies required for the next three months' work shall ordinarily be given by the Employer for his planning, procuring etc. The GFCD will be released as and when it is required without any delay to the successful Bidder after the issue of Letter of Acceptance and as specified in other sections of contract document.
- iv. The "Good for Construction" drawings which shall be issued to the Contractor by the Engineer after the award of work shall delineate the extent of work to be done by the Contractor.
- v. No deviation shall be made from these drawings by the contractor.
- vi.

c) Design, Drawings and Specifications for Temporary/ Ancillary works.

- i. Contractor's proposal for erection of all Ancillary and Temporary works shall be in conformity with the proposals submitted along with the bid and/or as approved by Engineer.
- ii. The contractor would design all the Ancillary and Temporary works including temporary supports, false work, formwork, staging scheme etc. and will submit the same and related working drawings to the Engineer for approval, after getting checked by an independent third-party designer. Bar Cutting and bending schedule for the reinforcement, shop drawings for fabrication work etc. shall also be prepared by the Contractor and submitted for Engineer's approval. Bend correction/Bend deduction shall be effected in bar bending schedule as per standard norms in consultation with the Engineer.
- iii. Shop Drawings
 - (a) Based on "Good for Construction" drawings issued by the Engineer the Contractor shall prepare shop/fabrication drawings to scale as specified, indicating the required details. The shop drawings shall be prepared before execution of work, after taking actual site dimensions and all existing and proposed services/structures etc.
 - (b) Shop/Fabrication drawings submitted by the Contractor shall be in sufficient detail to indicate the type, size, arrangement, breakdown for packing and shipment, the external connections, fixing arrangements required, the dimensions required for installation and interconnections with other equipment and materials, clearances and spaces required between various portions and any other information specifically called for.
 - (c) All reference points shall be in relation to the levels and locations, given in the relevant drawings and Services drawings duly cross-checked on site and confirmed. All locations and levels should be indicated with respect to grid and reduced levels with respect to the Bench Mark adopted for the Project and indicated in the drawings issued by the Engineer.

- (d) The Contractor shall verify the dimensions of all the necessary structural, architectural, Mechanical, Electrical & Plumbing (MEP) Services and other elements, relevant to the system being done, before proceeding with the preparation of the shop drawings and proceeding with the physical work at site and make suitable adjustments to accommodate within the spaces available.

Approval of Engineer of any such proposal / drawings shall not relieve the contractor of his responsibility of sufficiency of completion of the works

i. Drawing Management

- a) The Contractor shall submit all such drawings for Temporary / Ancillary works and shop drawings to the Engineer well in advance before he desires to commence the works and get the same approved from the Engineer. These drawings shall be submitted only after they have been duly detailed, checked and verified within the Contractor's organization ensuring that the details and data shown/furnished on the drawings are correct and that the requirements of other disciplines have been taken care of. The names and complete signatures of the Contractor's personnel responsible for the drawings shall be contained on each drawing. Any drawing which does not contain the above names and signatures shall be summarily returned to the Contractor and treated as not having been submitted.
- b) The drawings submitted for approval shall be in any one of the standard sizes – A0, A1, A2, A3 or A4, in accordance with Indian standards.
- c) All drawings shall show the following particulars in the lower right-hand corner in addition to the Contractor's name.
- Project Title
 - Name of the Employer
 - Name of Consultant
 - Contract No.
 - Title of Drawing.
 - Scale.
 - Date of Drawing.
 - Contractor's Drawing Number.
 - Space for the Engineer's drawing number.
 - Name of the Engineer.
 - Name of Review Consultant.
 - This drawing is based on Drawing No.(s).
 - Further detail is given on Drawing No.(s).
- d) Each drawing shall carry a revision number, date of revision and brief details of revisions carried out. Whenever any revision is carried out, the revision number must be updated. The revisions carried out on the drawing shall be clearly marked by

clouding and each cloud revision numbered by marking the revision number in triangle.

- e) All dimensions on drawings shall be metric units, unless otherwise specified. However, all levels shall be in meters.
- f) A template with the above information shall be got approved from BMRCL before start of the work.

- g) All shop drawings shall be prepared on CAD using AUTO-CAD Version 2010 or higher.

Shop drawings shall be prepared for the following works:

- Reinforcing bar bending schedules
- Working drawings for placing of reinforcement
- All form works, Shuttering and Scaffoldings
- Shop/Fabrication drawings for structural steel for PEB
- Metal work (ferrous and non-ferrous) for inserts, structural work in built up sections etc.
- Seismic joints
- Expansion joints
- Construction joints
- Waterproofing.
- any other works as per directions of Engineer.

- h) Drawing Management at Site

i. The Contractor shall ensure that all drawings (to be laminated at contractors cost) meant for further engineering, fabrication, erection and field work are issued to his personnel in a controlled manner - a proper record shall be maintained to show to whom the drawing is issued and to ensure that the latest revisions of the drawing is being followed for further work. All superseded drawings shall be promptly withdrawn from the personnel to whom they are issued and stamped "SUPERSEDED" in RED. The Contractor shall maintain a register of drawings, with their revision/issue number, as received from the Engineer and a record of their distribution to the designated personnel within their organization. A certificate to that effect along with list of drawings withdrawn during the month will be incorporated in the monthly progress report.

ii. The Contractor shall maintain at Site a set of the drawings issued by the Engineer on which changes shall be progressively marked and initialed by the Engineer so that "As-Built" drawings can be made correctly and expeditiously at the end of their Work at Site.

iii. Revision of Approved Drawings for Temporary/ Ancillary and Shop Drawings If, at any time before the completion of the Work, changes are made necessitating revision of approved Shop drawings/ drawings for Temporary/ Ancillary works, the

Contractor shall make such revisions and proceed in the same manner and observe procedure for obtaining approval of the Engineer as for the approval of the original drawings.

iv. Documents by Contractor

The contractor shall submit to the Engineer, for approval, Quality Assurance plans, design calculations, material specifications for each item and system, samples, as may be called for in the Specifications or as the Engineer may reasonably require. Wherever necessary the Contractor shall provide as built dimensions to facilitate proper Good for Construction drawings being prepared for various construction detailing.

v. Number of Copies of Drawings for Temporary/ Ancillary works/ Shop drawings and Documents

All Shop drawings / drawings for Temporary and Ancillary works, Documents, Schedules etc. and revisions thereof shall be submitted by the Contractor to the Engineer in 6 copies. Copies required in excess of these shall also be borne by the Contractor at his own cost.

d) Completion Drawings:

On completion of the work in all respects the contractor shall submit the following:

- Two sets of "As Built Drawings" in the standard sizes of A0, A1 each containing complete set of drawings for every component of work on approved scale indicating the work "As Built". Each set shall also contain technical literature.
These drawings shall be prepared on CAD using Auto-Cad version (latest/as directed by Engineer) and shall be recorded on writable CDs and one set of these CDs shall also be submitted.
- Four sets of catalogues of all manufactured materials with the name and addresses of the manufacturers for all equipment's provided by him.
- The Contractor shall also submit one set of original "As Built" drawings on polyester film or as directed by Engineer of quality as approved by Engineer/ Engineer's Representative.

The Certificate of Completion of Works as per the provisions in the General Conditions of Contract shall not be issued by the Engineer in the event of Contractor's failure to furnish aforesaid "As Built" drawings for the entire works.

e) Plans and Drawings for Layout of Plant and Equipment

The Contractor shall submit the following information, in triplicate, to the Engineer, for approval, within the time stipulated against each item given below:

- (a) A general layout plan for construction plant and equipment required for execution of work, within thirty days from the date of issue of "Letter of Acceptance".

- (b) drawings or prints showing the locations of major facilities which he proposes to put up at site, at least fourteen days prior to the commencement of the respective work; and
- (c) any other details and drawings as required under the contract, within the time as specified in the contract.

Cost of all the above activities shall be deemed to be included in the quoted rates of various items of the Bill of Quantities and nothing extra shall be paid for on this account.

12. TRAFFIC MANAGEMENT

- 12.1 The Contractor shall make the detailed traffic diversion plans in consultation with Bengaluru Traffic Police and get it approved by them. The work is to be executed with proper liaison with Bengaluru Traffic Police. The scheme should be such that minimum of two lane of traffic on each direction of the road should be available for the smooth flow of traffic. The Contractor shall inspect the site.
- 12.2 The traffic diversions will be carried out in consultation with traffic police during course of construction works. Contractor has to provide traffic diversion proposals, cones, traffic sign boards, reflective lights, rubber humps, temporary barricades etc., as desired by Traffic Police including making good the damage road due to metro construction activity up to their satisfaction. All the above said activities are included in contract and nothing extra shall be payable.
- 12.3 It includes but not limited to Diversion to other adjoining parallel roads or other suitable roads including strengthening of the same and all provision and maintaining the flow of traffic towards the diverted route with minimal inconvenience to the flow of affected traffic and close liaison with Traffic Department of Bengaluru.
- 12.4 The Contractor shall take necessary and adequate measures to ensure uninterrupted traffic flow within the work area during the currency of the work. It shall be the responsibility of the Contractor to provide suitable and acceptable diversions for the passage of the traffic. Contractor shall ensure that at no time, his construction equipment interrupts the movement of the traffic on the road.
- 12.5 The Contractor shall prepare a comprehensive Traffic Management Plan. The Contractor shall also draw a phased program for traffic arrangements / diversions and get it approved from the Engineer and Traffic Police well in advance with respect to every stage of construction.
- 12.6 If traffic diversions require construction of temporary roads and / or improvement of the existing roads, the design / drawings for the same including diversion of utilities etc. (if required) shall be prepared by the Contractor using the specifications not inferior to that of the existing roads / utilities and get it approved from the Engineer/Employer and Traffic Police. Payment for such diversion works and restoration works shall be made under relevant items of BOQ

- 12.7 Before taking up the work in a particular stretch, all the traffic diversions plan applicable to that particular area shall be implemented as per the approved plans / drawings and trial runs carried out to the entire satisfaction of Engineer / Traffic Police. If during trial runs some modifications are suggested, the same shall also be carried out before start of work.
- 12.8 The Contractor shall take all necessary measures for safety of traffic during construction and provide, erect and maintain such barricades (as approved by Engineer) having marking with reflective paint, signs /sign boards, pavement markings, flags, lights, traffic marshals and flagmen as may be required and / or directed by the Engineer for guiding, information and protection of the traffic approaching or passing through the stretch. Red lanterns or flashing warning lights of suitable type spaced at suitable intervals mounted on barricades along the diversions shall be provided, kept operational and maintained throughout from sunset to sunrise.
- 12.9 There could be locations where below the station structures, there is running traffic underneath which may not be stopped / diverted and will continue to move uninterrupted during construction and post -construction periods. In case of the pre-cast elements there could be locations where ground just below the launching area is not accessible or restricted due to traffic movement. The contractor should take care of these factors in to account while deciding the construction methodology / launching scheme for cast-in-situ / precast construction. Nothing extra will be paid for such eventualities.

13. LIGHTING AND FIRE PREVENTION:

- a) Wherever night working is carried out by Contractor, temporary lighting arrangements as per approved layout shall be provided, installed, maintained for the duration of the contract and removed after completion of work by and at the expense of the Contractor.
- b) Flashing lights to warn the traffic on roads shall be used at all times on all obstructions.
- c) Contractor shall provide and maintain adequate firefighting equipment and take adequate fire precautions for the safety of all personnel, plant, and material including temporary and permanent works and shall take action to prevent damage to or destruction by fire of trees, shrubs and grasses.
- d) No extra payment will be made for the provision of temporary lighting, flashing lights and fire prevention measures and entire cost of all such work shall be deemed to have been included in the costs of items of Bill of Quantities.

14. UTILITIES

All charted underground and overhead utilities have been shifted by BMRCL, whether it is temporary or permanent diversion. However, during execution of work if any uncharted utilities are met, the contractor shall temporarily support or temporarily divert the same at his own cost. In case if this is not possible as decided by Engineer, then the same will be permanently diverted by the contractor in consultation with the authority concerned and the payment will be made under respective item in the relevant payment schedule of Works under KPWD Common SR 2023-2024.

The tender utilities drawings are only indicative. Contractor should make his own survey for identification of underground/above ground utilities;

There is no charted utility (BWSSB pipeline, BESCOM, KPTCL, etc.) present in the alignment. Therefore, any utility encountered during the execution of work shall be treated as uncharted utility and contractor is responsible for shifting the same after liaising with the utility agency. For utility shifting payment will be made under the relevant contract schedule/ KPWD Common SR 2023-2024 as per contract terms.

14.2 Damage to Utilities

The contractor shall be responsible for any theft, damage and / or protection of all the existing utilities within the site of work during currency of the Contract. In case of any theft/ damage occurring to these utilities while working or otherwise, the contractor shall immediately inform the Engineer's representative as well the utility owning agency and restore the same immediately to the entire satisfaction of the utility owning agency. Any damage due to working / negligence / fault of the Contractor (decision of Engineer in this regard shall be final and binding), the same shall be repaired / made good by the Contractor at his own cost. Any damage/ compensation / penalty etc. if charged by the utility owning agency in this regard shall also be payable by the Contractor and no claim in this regard shall be entertained by the Employer. Contractor shall always keep indemnified the Engineer / Employer against this.

15. Barricading of Site and Work Areas

The contractor shall provide temporary barricade during construction at site, work areas (i.e. Construction Depot, store, site office, casting yard etc.) and locations where road vehicles / pedestrians are moving, along the Viaduct sites as directed by Engineer. The above work shall be executed as per the Technical Specifications. The contractor shall provide & maintain barricading as per the drawings.

16. INTERFACE WORKS

In addition, the Contractor shall be required to carry out various interface works as per interfacing requirements. An Approved Interfacing Manual - 'Project Wide Interface Document' will be supplied to the contractor, which needs to be followed by the contractor for all interfacing works.

17. RESPONSIBILITIES OF CONTRACTOR

17.1 Casting Yard

The land for setting up casting yard and stacking yard, Contractor will have to make his own arrangement for Casting Yard and his project office with the approval of Engineer and no extra payment shall be made on this account as detailed in Annexure-7.

Casting yard shall have following minimum facilities:

- a. Casting beds as required.
- b. Sets of form work / moulds as required.
- c. All handling facilities for precast elements like over gantry, etc.
- d. Curing arrangements as required.

- e. Stacking arrangements for material and precast elements.
- f. Storing arrangement of materials.
- g. Proper drainage and all-weather approach roads.
- h. Material testing laboratory and toilets for staff and workers.
- i. Any other left out arrangements as required to support casting/fabrication activities as directed by engineer time to time.

17.2 The Contractor shall provide and maintain at site throughout the period of works the following at his own cost and without extra charge, except for the items specified in the Bill of Quantities the cost being held to be included in the Contract Rates.

- 17.2.1** General works such as setting out, site clearance on completion of works. All weather approach roads to the site office should also be constructed and maintained in good condition.
- 17.2.2** All labour, materials, plant, equipment and temporary works, overhead charges as well as general liabilities, obligations, insurance and risks arising out of GCC, required completing and maintaining the works to the satisfaction of the Engineer.
- 17.2.3** Adequate lighting for night works/darkness in day, and also at other times whenever and wherever required by the Engineer.
- 17.2.4** All equipment, instruments, labour and materials required by the Engineer for checking alignment, levels, slopes and evenness of surfaces measurements and quality etc. Shall be arranged by the contractor
- 17.2.5** Design mixes and testing them as per relevant clauses of specifications giving proportion of ingredients, sources of aggregates and binder along with accompanying trial mixes. Test results to be submitted to the Engineer for his approval before adoption on works.
- 17.2.6** Method Statements, for each main activity of the work (temporary and permanent) to be executed detailing the purpose, scope, resources required, sequence / procedure of execution, persons responsible, time frame, safety requirements & measures, risk analysis, Inspections, and Test Procedures along with standard values / acceptable criteria etc. duly approved by the Engineer before start of that particular activity at site.
- 17.2.7** Contractor shall also prepare/approve and make available to the Site Engineer the work procedure for each sub-activity to be done at the site, detailing the procedure / process to be followed including work sequence, safety measures, to be followed, level of quality to be maintained, type of material to be used, type of finishing required and responsibility assigned etc.
- 17.2.8** Preparation and compliance with provision of a quality assurance control programme.
- 17.2.9** Prepare and submit Standard Quantities for the purpose of billing based on the approved drawings.

17.2.10 Cost of safety measures and requirements of site safety plan

- The Contractor shall make adequate security arrangements for 24x7 protection of Temporary and permanent works and deployed resources.
- The Contractor shall be responsible for the security of the Site for the full time the Site is in its possession, except for the specific case after handover to the Employer. The contractor shall set up and operate a system whereby only those persons entitled to be on the Site can enter the Site. To this end, the Contractor shall with the consent of Engineer provide the specific points only at which entry through the security fence can be affected and shall provide gates and barriers at such points of entry and whereby maintain a twenty-four (24) hours security guard, and such other security personnel and patrols elsewhere as may be necessary to maintain security.
- The Contractor shall maintain all site boundary fences in good condition and shall so arrange site boundary fences at all access drainage points of work areas that it's use of such access points etc., are not restricted by the system or method of achieving the required security measures. Notices shall be displayed at intervals around the Site to warn the public of the dangers of entering the Site.
- During the progress of the Works the Contractor shall maintain such additional security patrols over the areas of the Works as may be necessary to protect its own and its sub-contractor's work and equipment and shall co-ordinate and plan the security of both the work under this Contract and the work of others having access to and across the Site and the Works.
- In order to operate such a security system, it will be necessary to initiate the issue of unique passes to personnel and vehicles entitled to be on the Site, and which may need to be separately identifiable according to the shifts being worked on Site. The Contractor shall at the outset determine, together with the Engineer, a system and the design of passes to suit the requirements of the foregoing and to suit the methods of work to be adopted by the Contractor. The Contractor shall at all times ensure that the Engineer has an up to date list of all persons entitled to be on the Site at any time. The contractor shall also introduce a system of issue passes to any outsider or person/vehicles belonging to agencies other than employer/ Engineers who may have to visit the site in connection with work
- The Contractor shall liaise with the Designated Contractors and the contractors responsible for the adjacent and other interfacing contracts and ensure that coordinated security procedures are operated, in particular in respect of vehicles permitted to pass through the Site and/or the adjacent sites in the latter periods of the Contract.
- Security and checking arrangements as felt necessary shall be provided with advice and help of Police.

17.2.11 Safe guarding the environment.**17.2.12 The contractor shall carry out expeditiously and without delay the following works:**

- a. Identify and get approved the sources of various major construction materials.
- b. Material testing and mix designs of concrete as contemplated in the specifications.
- c. Setting up of fully fledged site laboratory as per the requirements.
- d. Setting up concrete batching & mixing plant, if required.

- e. Contractor's site office setup.
- f. Casting yard with complete facilities.
- g. Any other pre-requisite items required for final execution.
- h. Any other items specified in other sections of contract.
- i. Identification of utilities/obstructions and diversion/demolition.

18. ASSOCIATED WORKS DEEMED INCLUDED IN ITEM RATES OF PERMANENT WORKS

18.1 Contractor's Organization and Plant & Equipment Project Organization Plan

- 1) The Contractor's Personnel shall be deployed & maintained in consultation with Engineer and as per the requirements. The Contractor's Superintendence shall also be properly deployed and maintained to carry out the construction activities as described in Sub-clause 6.8 [Contractor's Superintendence] in the General Conditions of Contract (GCC).
- 2) The Contractor shall submit an updated Project Organization Plan which includes complete project organization chart during the Construction Phase adding functions and personnel necessary to perform the Works during the Construction Phase in accordance with the conditions of the Contract. This plan shall be updated and resubmitted whenever there are changes to the staff and / or the organizational structure. The plan shall show the management structure and state clearly the duties, responsibilities and authority of key staff member.
- 3) The contractor shall deploy the key personnel of requisite qualification and experiences. In case Engineer instructs (in writing) the Contractor to remove a person of his work force stating the reasons, the Contractor shall ensure that the person leaves the Work Area within seven days and shall have no further connection with the Works in the Contract. The Engineer shall also seek prior consent of the Employer in this regard.
- 4) During the Construction Phase, the Contractor shall maintain the Design Team in his organization independent of the Construction Team to deal with temporary works design and working drawings.
- 5) The minimum requirements for man-power are attached as **Annexure-4 [Organisation chart and key positions]** to the Employer's Requirement

Plant and Equipment:

- 1) The minimum Plant and equipment as shall be maintained in consultation with Engineer and as per the requirements.
- 2) The minimum requirements for plant & equipment are attached as **Annexure-6 [Plant and Equipment]** to the Employer's Requirement

19. PENALTY FOR NON-COMPLIANCE

Notwithstanding the provisions elsewhere in the bid documents, the Contractor shall be penalized as detailed below:

a) Correction of Defects

If the Engineer determines that any item or part of it was constructed with bad workmanship and / or using sub-standard construction materials,

Sl. No.	Nature of Defects	Penalty (Rs.)
1.	Not maintaining plumb line, level in concrete works / observing honey combs on the finished surface of concrete	1,00,000/- each case
2.	Usage of unapproved / sub-standard materials	2,00,000/- each case

The above said penalty is envisaged to act as deterrent against bad workmanship and usage of sub-standard construction materials by the Contractor and shall be imposed for every occurrence. These penalties are non-refundable.

Annexure-1

1. PROGRAMME REQUIREMENTS

1.1 GENERAL

1.1.1 CONSTRUCTION PROGRAMME AND PROJECT MONITORING

- a) The contractor shall propose and submit his detailed construction program separately and as per the procedure detailed in Scope of work. Contractor may be asked to schedule and complete the work block wise / area wise in a phased manner fixing priorities to different stretches of the work to give access to other interfacing contracts as mentioned in the Bid documents.
- b) The tentative construction program shall be submitted within the period as specified in General Conditions of Contract for approval of the Engineer as 'Baseline Program'. The base line program shall clearly reflect interface and access dates for other civil/ system-wide contracts. The basis of the time schedule for each activity such as productivity of man and machines and time cycle of each activity and resource planning shall be submitted along with the base line program.
 - i) After the work has started, the Contractor shall deliver in the first week of every month to the Engineer an update of the Construction Program showing changes, if any, in planning or progress scheduling and reflecting the progress of all the activities of the network and the project status as at the end of previous month.
 - ii) If the Contractor falls behind the approved Construction Program by more than one month, he shall, within fourteen days of the date of such information, submit for approval, a revision of the construction program showing the proposed measures, including augmentation of plant, labour and material resources to complete the works on time.
 - iii) Whenever the Contractor proposes to change the construction program, he shall immediately advise the Engineer in writing and, if the Engineer considers the change a major one, the Contractor shall submit a revised program for approval.
 - iv) Detailed Network Plan (Works Program)

Detailed Network Plan shall be prepared by the Contractor for each and every activity within the same time frame and in the same sequence. Activity at this level shall not be more than 15 days' duration, except for summary items like procurement/ mobilization etc.

- c) The Contractor shall select a PC-based broad planning and control software (licensed version of Primavera, M.S. Projects etc.). The two networks shall be implemented on works as detailed in the Scope of work. The Contractor shall supply one original licensed copy of the software selected including manuals and any subsequent versions thereof at no extra cost along with the Baseline program network and detailed network plan and load it on the PC system of the Engineer so that uniform monitoring of the project is done and any slippages are identified well in time and corrective action taken. The contractor shall also arrange suitable training of the personnel of Engineer on the selected software, if required, at no extra cost.
- d) The following reports, in agreed formats and frequency, shall be submitted by the Contractor at his own cost:
 - i. Progress Reports
 - ii. Material Status Reports
 - iii. Equipment and Manpower Deployment Reports
 - iv. Obstacles/hindrances Report.
 - v. Any other Report desired by the Employer or the Engineer

- e) The Engineer's monitoring team will have access to all the data/information of the Contractor, required for the assessment of the progress and monitoring. If necessary, the monitoring team will visit the Vendor/Contractor's works in order to assess the status of critical activities.
- f) Periodic Project Status Review Meetings will be held by the Employer or the Engineer. The Contractor shall depute his Engineers/Managers at appropriate level as decided by the Engineer to attend the Review Meetings.
- g) Progress photographs of the major events shall be submitted by the Contractor along with the Progress Reports. Video Recording of the progress of works shall be maintained from beginning till completion of work as directed by the Engineer.
- h) The Contractor shall provide additional inputs whenever the PERT-CPM/ network diagram (Primavera/ MS Projects) indicates a possible slippage in the completion schedule. Such additional inputs may require supplementing of equipment, personnel, work in excess of the normal work per day, and work in excess of the normal work per week or other resources. Provisions in the relevant Clause of General Conditions of Contract will be applicable in cases of delays due to Contractor.

1.1.2 Purpose of Program

- a) The purpose for the requirement of Program (Scheduling) information described in this document is to provide the Engineer with status reports for managing, monitoring and coordinating the awarded contract during the execution within the overall multi-contract project schedule. It describes a series of reports to be submitted by the Contractor to the Engineer during the execution of the contract, following the award of Contract.
- b) The Bidder/ Contractor shall program his work at all times to meet the Key Dates and the Works Area Hand-over Dates specified in the bid documents and the specified interface periods for the design and installation of the Works with those of the Designated Contractors and shall during the progress of the Works constantly monitor his progress against the programs described below.
- c) The Bidder/ Contractor shall include in all programs his work obligations towards shared access, shared Site areas and other coincident or adjacent Works Areas.
- d) The Works Program, and all more detailed or revised versions, shall be submitted to the Engineer for his consent.

1.2 METHODOLOGY

- 1.2.1 The computerized MSP/Primavera network using the Precedence Diagramming Method (PDM) has been selected by the Employer as the technique for contract management system and in coordinating the multi-contract project. This technique shall also be employed by the Bidder in preparing their Bid submissions and by the Contractor in their Construction Stage submissions.

- 1.2.2 Unless otherwise agreed by the Engineer, all programs submitted by the Contractor shall be produced using computerized MSP/Primavera Networks developed implementing the Precedence Diagramming Method (PDM) with Resource Loaded Charts and Tables.
- 1.2.3 The Contractor shall implement and use throughout the duration of the Contract, a computerized system to plan, execute, maintain and manage the planning, design, pre-construction, construction, and sub-contracts in executing the MSP / Primavera scheduling by PDM. The reports, documents and data shall be provided monthly and shall be an accurate representation of the current status of the Works and of the work remaining to be accomplished; work planned to be taken up during next month, shall provide a sound basis for identifying problems, deviations from the planned works, and for making decisions; and shall enable timely preparation of the same for presentation to the Engineer.

1.3 PROGRAMME MANAGEMENT SOFTWARE

MSP/Primavera programming software used shall be Primavera-v P 6 Scheduling Software.

1.4 SUBMISSIONS

- 1.4.1 The Contractor shall develop his Program into the Initial Works Program including an outline Narrative Statement and submit within 28 days of the date of receipt of Letter of acceptance and its more detailed version within 21 days of receiving the Engineer's consent to the proposed Initial Works Program.
- 1.4.2 Activities in the initial works program should be arranged as per the Works Break down Structure (WBS) of the work. The WBS of the work would be developed by the contractor in consultation with the Engineer. Contractor would get the WBS approved by the Engineer and the program expert.
- 1.4.3 The first Three Month Rolling Program shall also be submitted along with Initial Works Program within 28 days of the date of receipt of Letter of Acceptance and all subsequent editions shall accompany the Monthly Progress Report. The Monthly Progress Reports shall also include a Program Update as described below. These programs shall subsequently be updated as described below.
- 1.4.4 Following the Engineer's consent to Contractor's Initial Works Program submission, the contractor shall make submissions of the Detailed **Works Program** suitably amended to take into account the programs of Designated Contracts. It is the Contractor's responsibility to ensure timely co-ordination with the Designated Contractors to review, revise and finalize his Initial Work Program so as not to affect the progress of Works/ and or the works of the Interfacing Contractors. The resubmitted program when approved by the Engineer and the program expert shall form the **Baseline Program** against which actual progress of the Contract shall be reckoned. As the work progresses, it may be necessary to update/ revise the Baseline program but such updating shall only be carried out with the prior consent of the Engineer or when directed by them.

- 1.4.5 For Initial & Detail Work Program submission, one (1) original and six (6) copies each (along with electronic copy) of the following Programs and Reports shall be submitted to the Engineer:
- a) Program: Baseline MSP / Primavera Network
 - b) Program: Baseline Milestone based Cost Activity Schedule
 - c) Baseline Schedule Report
 - d) Narrative
 - e) Baseline Physical Progress 'S' curve
 - f) Baseline Resource Charts (with Resource leveling)
 - g) Detailed Method Statement
- 1.4.6 The Engineer shall review and comment on the Contractor's programs and information submitted. The Engineer will confirm his consent or otherwise of the submissions.
- 1.4.7 The Engineer shall require the Contractor to re-submit within fourteen (14) calendar days if he is of the opinion that the programs and information submitted by the Contractor is unlikely to meet the Contract key dates.
- 1.4.8 If in the opinion of the Engineer, any of the Contractor's revised programs or Baseline Schedule Report is not acceptable, it shall be construed as a failure of the Contractor to meet a Milestone.
- 1.4.9 Notwithstanding the above, the Engineer may at any time during the course of the Contract require the Contractor to reproduce the computer-generated Baseline Schedule Report described above to reflect actual activity dates and generate schedules based upon "what if" statements. The initial computer-generated report after receiving the Engineer's consent will serve as the base against which the contract progress will be measured. Any changes to the Report reflected in subsequent Baseline Schedule Reports shall also require the Engineer's consent.
- 1.4.10 Failure to include any element of work required for performance of the Contract shall not relieve the Contractor from completing all works required under the Contract to achieve the original or any extended key completion date.

1.5 WORKS PROGRAMME

- 1.5.1 The Works Program shall show the Contractor's plan for organizing and carrying out whole of the Works.
- 1.5.2 The Works Program shall be a computerized MSP/Primavera network developed using the Precedence Diagramming Method (PDM) and shall be present in bar chart and time-scaled network diagram format to a weekly time scale.
- 1.5.3 Tasks in the Works Programme shall be sufficiently detailed to describe activities and events that include, but are not limited to, the following:
- (a) Key Dates, and Works Area Hand-over Dates and Interface dates.
 - (b) all physical work to be undertaken in the performance of the Contract obligations, including Temporary Works,
 - (c) the requested date for issue of any drawings or information by the Engineer,
 - (d) procurement of major materials and the delivery and/or partial delivery date on-Site of principal items of Contractor's Equipment,
 - (e) commissioning date of Contractor's major equipment,
 - (f) any off-site work such as production or pre-fabrication of components,

- (g) installation of temporary construction facilities,
- (h) interface periods with Designated Contractors or utility undertakings,
- (i) design, supply and/or construction activities of sub-contractors,
- (j) any outside influence which will or may affect the Works.

- 1.5.4 The Works Program shall show achievement of all Key Dates, Interface dates and Works Area Hand-over Dates. The Works Program shall also show all Milestones, but the Milestones shall not be taken as imposing any constraints that in any way affect the logic or limit any other dates in the program.
- 1.5.5 Activity descriptions shall be unique, describing discrete elements of work. Any activity creating an imposed time or other constraint shall be fully defined by the Contractor.
- 1.5.6 The Works Programme shall be organized in a logical work-breakdown-structure including work stages and phases, and shall clearly indicate the critical path(s).
- 1.5.7 Activity duration shall not exceed 15 days, unless otherwise consented to by the Engineer, except non-construction activities such as submittals, submittal reviews, procurement and delivery of materials or equipment and concrete curing. The Contractor shall submit a Program/Project Calendar cross reference clearly indicating the allowance for holidays.
- 1.5.8 The Works Program, in each submission, shall be accompanied by an Activity Report and a Narrative Statement as described below in both electronic and hard copy format (time scale logic diagrams in A1/A3 size, reports in A4 size).
- 1.5.9 **Activity Report** shall list all activities, and events in the Works Program, sorted by activity identification number.

The Activity Report shall include the following for each activity and event:

- Activity identification number and description,
- Duration expressed in Days,
- Early and late start & early and late finish dates. Planned start and finish dates,
- Calculated total float and free float,
- Predecessor and successor(s), accompanying relationships and lead/lag duration,
- Imposed time or date constraints,
- Calendar.

1.5.10 Narrative Statement

The Narrative shall be a comprehensive statement of the Contractor's plan and approach for the execution of the Works and the achievement of key dates, handover dates, submission dates and any intermediate dates. It shall incorporate outline method statements in respect of major items of work including construction sequences, launching scheme, resources required including primary item of plant, Construction Equipment required, person responsible, quality checks, inspection and test procedures, tolerances, Temporary Works and the like, risk analysis, etc. for carrying out that activity. It shall fully explain the reasons for the main logic links in the Program and include particulars of how activity duration is established. This shall

include estimated quantities, production rates, hours per shift, work days per week and a listing of the major items of Construction Equipment planned for use on the project. Activities, which may be expedited by use of overtime or additional shifts, shall be identified and explained. A listing of holidays, and other special non-work days being used for the computer reports shall be included.

1.5.11 Baseline Physical Progress 'S' Curve

The Contractor shall also submit a forecast Cumulative Physical Progress 'S' curve based on the time-phased distribution of cost in the MSP / Primavera Network Logic Diagram, expressed in percentage terms. This 'S' curve shall be generated from the computerized MSP / Primavera Network Logic Diagram.

1.5.12 Baseline Resource Charts

The Contractor shall also submit a Resource Charts, generated from the Contractor's MSP / Primavera Network Diagram, showing the anticipated manpower and main Construction Equipment usage during the execution of the Project. The Resources shall be properly leveled using Primavera VP6 software.

All submissions of proposed Works Programs subsequently, after approval of the Initial Works Program, shall include the actual physical progress of work and forecast of the remaining work. Actual progress shall be stated in percent complete, remaining duration, and actual start and finish dates for each activity in the Works Program.

1.6 INITIAL WORKS PROGRAMME

- 1.6.1** The Initial Works Program submitted as under Clause 1.4.1 need not include the full details given under Clause 1.5 above. It should be a condensed version with combined activities of longer duration but must show clearly how the requirements of the Contract are to be achieved. Activities in the initial works program should be arranged as per the Works Break down Structure (WBS) of the work. The WBS of the work would be developed by the contractor in consultation with the Engineer. Contractor would get the WBS approved by the Engineer. The outline Narrative Statement shall be in sufficient detail to clearly show the Contractor's intention.
- 1.6.2** Within 21 days of the Engineer's consent to the Initial Works Program, the Contractor shall submit to the Engineer an expanded and more detailed version of the Initial Works Program containing all of the information and detail required under Clause 1.4 and 1.5 above.
- 1.6.3** Such submission shall make use of the Program submitted earlier but refined to include the best estimates of dates for the work of Designated Contracts which has impact on the Contractor's program. Such programs shall be amended subsequently to incorporate the actual dates/ schedule of the affecting contracts. It is the Contractor's responsibility to ensure timely co-ordination with the Designated Contractors to finalize the Initial Program, without affecting progress of the work.

1.7 WORKS PROGRAMME REVISIONS

- 1.7.1 The Contractor shall immediately notify the Engineer in writing of the need for any changes in the Works Program, whether due to a change of intention or of circumstances or for any other reason. Where such proposed change affects timely completion of the Works or any other Key Date the Contractor shall within fourteen (14) days of the date of notifying the Engineer submit for the Engineer's consent its proposed revised Works Program and accompanying Narrative Statement. The proposed revised Works Program shall show the sequence of operations of any and all works related to the change and the impact of changed work or changed conditions.
- 1.7.2 If at any time the Engineer considers the actual or anticipated progress of the work reflects a significant deviation from the Works Program, he may request the Contractor to submit a proposed revised Program which together with an accompanying Activity Report and Narrative Statement, shall be submitted by the Contractor within fourteen (14) days after the Engineer's instruction. The proposed revised Works Program shall show the sequence of operations of any and all work related to the change and the impact of changed work or changed conditions. Revisions should not affect the overall completion of the project.
- 1.7.3 All activities that have negative float must be analyzed by the Contractor to identify the impact on the timely completion of the Works or on the achievement of Key Dates.

1.8 THREE MONTHS ROLLING PROGRAMME

- 1.8.1 The Three-Month Rolling Program shall be an expansion of the Detailed Works Program, covering sequential periods of three months. The Three-Month Rolling Program shall provide more detail of the Contractor's plan, organization and execution of the work within these periods. In particular, the Contractor shall expand each activity planned to occur during the next three (3) month period, if necessary, to a daily level of detail.
- 1.8.2 The Three-Month Rolling Program shall be developed as a MSP/Primavera network, and shall be presented in bar chart and time-scaled network diagram format. Bar charts shall be presented on an A4 and time-scaled networks diagrams on an A3 size reproducible media. Tasks in the program shall be derivatives of and directly related to tasks in the approved Works Program.
- 1.8.3 The Contractor shall describe the discrete work elements and work element inter-relationships necessary to complete all works and any separable parts thereof including work assigned to sub-contractors within the contract period.
- 1.8.4 Activity duration shall not exceed two (2) weeks unless otherwise consented to by the Engineer.
- 1.8.5 Each activity in the Three-Month Rolling Program shall be coded, or described so as clearly to indicate the corresponding activity in the Works Program.

1.9 THREE MONTHS ROLLING PROGRAMME REVISIONS AND UPDATE

- 1.9.1 The Three-Month Rolling Program shall be extended forward each month as described under Clause 1.8.1 above. Each submission of the Three-Month Rolling Program shall be accompanied by a Program Analysis Report, describing actual progress to date, and the forecast for activities

occurring over the next three-month period in order to achieve progress as per the approved Works Program.

- 1.9.2 If the Three-Month Rolling Program is at variance with the Works Program, the Program Analysis Report shall be accompanied by a supporting Narrative Statement describing the Contractor's plan for the execution of the activities to be undertaken over the three-month period, including program assumptions and methods to be employed in achieving timely completion.
- 1.9.3 The Contractor shall revise the Three-Month Rolling Program or propose revisions of the Works Program, or both, on a monthly basis to ensure consistency between them.
- 1.9.4 Three-Month Rolling Program (revised) to be submitted on a monthly basis by 5th of every month with respect to the progress achieved by the last day of the previous month. A penalty of Rs. 1,00,000/- (Rupees One Lakh only) per instance will become applicable to the contractor for non-submission of the revised Three-monthly rolling program as per above clauses, irrespective of the causes lead to variances if any and the penalty will be deducted in the subsequent IPC which will be non-refundable.

1.10 WEEKLY REVIEW

Once a week, on a day mutually agreed by the Engineer and the Contractor, a meeting will be held to assess progress by the Contractor during the previous week, progress review which will also be attended by the programs Expert, Contractor's Program Engineer and Key persons deployed by contractor for physical activities at site as desired by the engineer. The Contractor shall submit a construction schedule listing activity completed and in-progress from the previous week and the activities scheduled for the succeeding two weeks based on the detailed Works Program. Copies of the schedule shall be submitted on A3 sized papers.

1.11 PROJECT CALENDAR

For the Project, the Contractor shall adopt 7 days a week calendar, identical calendar for the purpose of programming and Execution of Works. Official documents shall be transacted during 6 days' week – Monday through Saturday. For Project purposes, a week begins at 0001 hours on a Monday and ends at 2359 hours on a Sunday. The completion of an activity or the achievement of an event when given a week number shall be taken to mean midnight on the Sunday at the end of the numbered week. An access date or activity start date when given as a week number shall be taken to mean 0001 hours on a Monday of the Numbered week.

1.12 PROGRAMMING PERSONNEL

The Contractor shall submit, as part of its Staff Organization Plan, the names and required information for the staff to be employed on Works Programming. The principal Works Programmer shall hold reputable professional qualifications acceptable to the Engineer including at least five (5) years relevant experience in programming civil engineering works. Others in the group shall have at least three (3) years' experience in such work. The programmers shall be employed by the Contractor full time on the Contract until the completion or such earlier time the Engineer may give his consent.

1.13 PROGRAMME AND REPORT SUBMISSION FORMAT

The Contractor shall submit hard copy of one (1) original and six (6) copies and one (1) reproducible (for Programs) of all submissions to the Engineer. All submissions shall be in A0, A1, A3 or A4 size, as appropriate except as may otherwise be agreed by the Engineer. In addition, the computerized program and report shall be submitted in compatible discs. The format for all Program and Report submissions shall be strictly in accordance with the format as stated herein or as requested by the Engineer.

2. MONTHLY PROGRESS REPORTS

2.1 GENERAL

The Contractor shall submit to the Engineer, a Monthly Progress Report. This Report shall be submitted by the end of each calendar month and shall account for all work actually performed from 26th day of the last month and up to and including the twenty-fifth (25th) day of the month of the submission. It shall be submitted in a format to which the Engineer shall have given his consent and shall contain sections/sub-sections for, but not be limited to, the topics listed in clauses below.

2.2 PHYSICAL PROGRESS

- a) It shall describe the status of work performed, significant accomplishments, including critical items and problem areas, corrective actions taken or planned and other pertinent activities, and shall, in particular, address interface issues, problems and resolutions.
- b) It shall include a simplified representation of progress measured in percentage terms compared with percentage planned as derived from the Works Program.

2.3 PROGRAMME UPDATE (For Entire Project)

Program updating shall include: -

- (a) the monthly Program Update which shall be prepared by recording actual activity completion dates and percentage of activities completed up to the twenty-fifth (25th) of the month together with estimates of remaining duration and expected activity completion based on current progress. The Program Update shall be accompanied by an Activity Report and a Narrative Statement. The Narrative Statement shall explain the basis of the Contractor's submittal:
 - (i) Early Work and Baseline Submittals – explains determination of activity duration and describes the Contractor's approach for meeting required Key Dates as specified in the Contract.
 - (ii) Updated Detail Program Submittals – state in narrative the Works actually completed and reflected along Critical Path in terms of days ahead or behind allowable dates. Specific requirements of narrative are:
 - If the Updated Detailed Work Programme indicates an actual or potential delay to Contract Completion date or Key Dates, identify causes of delays and provide explanation of Work affected and proposed corrective action to meet Key Dates or mitigate potential delays. Identify deviation from previous month's critical path.

- Identify by activity number and description, activities in progress and activities scheduled to be completed.
- Discuss Variation Order Work Items, if any.

(b) The Program Status which shall: -

- (i) Show Works Program status up to and including the current report period, display Cumulative progress to date and a forecast of remaining work.
 - (ii) Be presented as a bar-chart size A3 or A4 and as a time-related logic network diagram on an A1 media, including activity listings;
- (c) The Activity Variance Analysis which shall analyze activities planned to start prior to or during the report period but not started at the end of the report period as well as activities started and/or completed in advance of the Works Program.

2.4 THREE MONTHS ROLLING PROGRAMME

The monthly issue of the Three-Month Rolling Program.

2.5 FINANCIAL STATUS

It should include following: -

- a) A narrative review of all significant financial matters, and actions proposed or taken in respect to any outstanding matters.
- b) A spread sheet indicating the status of all payments due and made.
- c) A status report on status of extra items, if any.

2.6 STATUS OF CLAIMS

A report on the status of any outstanding claims. The report shall in particular provide interim updated accounts of continuing claims.

2.7 MILESTONE / KEY DATES STATUS

A report on the status of all milestones/ key dates due to have been achieved during the month and forecasts of achievement of any non-achieved key dates and those due in the next month

2.8 RESOURCES STATUS

- 2.8.1 The Contractor shall submit to the Engineer each month a detailed list by trade classification, of manpower employed during the report period, stock of all major construction materials also a list of all serviceable major items of construction, plant and equipment on site including those which are proposed to be mobilized during the next month.

- 2.8.2** A report on the status of deployment of all key personnel and other manpower by trade Vis – a - Vis their deployment schedule and explaining constraints if any.
- 2.8.3** Status of stock of all the major construction material vis -a- vis its requirements for next month.
- 2.8.4** Status of all serviceable major construction plant and equipment at site.

2.9 PROCUREMENT REPORT

- 2.9.1** A summary of all significant procurement activities during the month, including reasons of delay (if any) and action taken to overcome problems.
- 2.9.2** A report listing major items of plant and materials which will be incorporated into the Works. The items shall be segregated by type as listed in the Specifications and the report should show as a minimum the following activities:
- (a) purchase Order Date – Scheduled/ Actual,
 - (b) manufacturer/ Supplier and Origin,
 - (c) letter of Credit Issued Date,
 - (d) manufacturer/ Supplier Ship Date – Scheduled/ Actual,
 - (e) method of Shipment,
 - (f) Arrival date at site and commissioning date

The report should also explain the delays (if any) in arrivals of the major equipment at site and the actions taken by the Contractor to expedite the same and the measures proposed to makeup the time loss.

2.10 PRODUCTION AND TESTING

It should include following: -

- (a) A review of all production and manufacturing activities during the month.
- (b) Summaries of all production and manufacturing outputs during the month together with forecasts for the next month.
- (c) Review of all testing activities (both at site and at the manufacturer's premises) during the month.

2.11 SAFETY

A review of all safety aspects during the month including safety inspections / audits, reports on all accidents and actions proposed to prevent further occurrence. Safety meeting shall be attended by the contractor along with his EHS key personnel every week and as and when Engineer desires.

2.12 ENVIRONMENTAL

A review of all the environmental issues during the past month to include all monitoring reports, mitigation measures undertaken, and activities to control environmental impacts. The reports

shall be in accordance of the guidelines laid by the project funding agency as directed by the engineer.

- 2.13 In case of failure of the Contractor to make submissions as per section 1.4 herein above, the Employer/ Engineer shall retain 5% of the due progress payment till the submissions. For non-submission of Monthly Update and Progress Reports as per Clause 2 herein above, the Employer/ Engineer shall retain 5% of the due progress payment in each case, which shall be released upon submission of the same. In case the submissions are not made in the month it is due, the retained payment would be released only in the next Monthly Running Bill.

Annexure-2**METHOD OF MEASUREMENTS FOR PERMANENT WORKS****1. INTRODUCTION**

- 1.1 The detailed procedure to be followed for the recording of measurements and for the preparation and passing of Contractors Bills for permanent works is set out in the following paragraphs.

2. MEASUREMENT OF WORKS**2.1 General**

- 2.1.1 Measurements shall be taken at such intervals as are found necessary or convenient. Generally, one bill will be preferred in a month or as specified in the contract.
- 2.1.2 Entries should be made only in ink, and no entry should be erased or defaced so as to make it illegible. Correction of mistake, if any, shall be made by neatly crossing out the incorrect entry and rewriting and correct words or figures. All such corrections should be initialed by the Contractor's Engineer as well as by the Engineer's Representative at site.
- 2.1.3 Format of Record of Measurements sheets and procedure for issue of these measurement sheets shall be as decided by Engineer/Employer.

2.2 Items for which Good-for-Construction Drawing is issued

- 2.2.1 As soon as the Good-For-Construction drawing for a work is issued, the Contractor will calculate the details of quantities of various items of Bill of Quantities (BOQ) involved, in a format approved by Engineer, and submit the calculations and schedule of quantities to the Engineer/Engineer's Representative and get them approved for the drawing.
- 2.2.2 Once the schedule of quantities is thus approved, the Contractor will submit five copies of the approved schedule to Engineer's Representative in an approved format.
- 2.2.3 The Contractor will submit his payment claims based on the approved schedule of quantities along with certification of actual work done as per specifications, drawings and contract conditions and within the tolerances as specified. Measurement will be entered in Record of Measurement Sheet duly signed jointly on each page by Contractor's authorized qualified engineer and Engineer's Representative.
- 2.2.4 Abstract of measurement will be prepared by the contractor in the approved form based upon these measurements.

2.3 Items for which Good-For-Construction Drawing is not issued

- 2.3.1 For all such works, whose measurement cannot be calculated from any Good-For-Construction drawing, all measurements will be taken by the Contractor's authorized qualified Engineer in the presence of the Engineer's Representative at site. These measurements will be recorded on approved form of Record Measurement Sheet and signed jointly by contractor and Engineer's Representative.
- 2.3.2 Contractor will ensure that a properly qualified Engineer is deputed for taking measurements and also that all the measurements taken are witnessed and signed by the Engineer's Representative.
- 2.3.3 All measurements should be recorded at site on the Record of Measurement Sheet in the presence of the Engineer's Representative.
- 2.3.4 Each Measurement Sheet should be signed by the Contractor's Engineer as well as by the witnessing Engineer's Representative.
- 2.3.5 Based on the recorded measurement contractor will prepare abstract of quantities in the approved format.

Annexure-3

QUALITY ASSURANCE

1.1 General

The Contractor shall implement a Project Quality Management Plan in accordance with ISO-9001 "Quality System – Model for Quality Assurance in Design/Development, Production, Installation and Servicing" or any other system as approved by Engineer to ensure that all materials, workmanship, plant and equipment supplied and work done under the contract meets the requirements of the contract. This plan shall apply to all activities related to the quality of items, including designing, purchasing, inspecting, handling, assembling, testing, storing, and shipping of materials and equipment and different elements of construction work and installations of system components.

The Quality Plan to be prepared by the Contractor and submitted to the Engineer shall follow the requirements of ISO 9001 and address each element therein. This Quality Plan/QA manual, specific to this work must be submitted within one month of award of contract.

Running on account payment will be released after the following milestones are achieved and Engineer has issued a 'Notice of No Objection' or a Notice of No Objection subject to (specifying the condition)'.

- a. Release of on-account payment after two months of signing the contract agreement – On submittal of QA Manual duly approved by Engineer. Otherwise 10% of the running bill be withheld till compliance.
- b. Closure of Non-conformance Report – Action taken on non-compliance and its closure to be ensured within 15 days of issue of non-conformance report. In case of non-closure of report, running on-account bill will be withheld @ 1 % of amount for every non closure, till the same are closed satisfactorily.
- c. Release of on-account payment after four months and thereafter every 3 months from the date of start of work – On submittal of Internal Quality Audit Report duly reviewed by Engineer and Action Taken Report. Otherwise 10% of the running bill be withheld till compliance.
- d. Release of Final bill
 - i) Closure of all non-conformance Report
 - ii) Submittal of all quality documented record pertaining to monitoring and accountability including QA Manual & Procedures

Registration of the Contractor's organization, or subcontractors or sub-consultants is not required for this Project but the Project Quality Management Plan as submitted shall meet the intent of the ISO 9001 requirement in that there is a comprehensive and documented approach to achieving the project quality requirements.

1.2 Quality Assurance Management Plan

The Project Quality Management Plan (PQMP) shall as a minimum, address the quality system elements as required by ISO 9001, generally noting the applicability to the Contractor's Works Program for the Project. Procedures or Quality Plans to be prepared by others (Suppliers, Subcontractors, Sub-consultants) and their incorporation in the overall PQMP shall be identified.

The Contractor shall provide and maintain a Quality Assurance Plan (QA) to regulate methods, procedures, and processes to ensure compliance with the Contract requirements. The QA Plan, including QA written procedures, shall be submitted to the Engineer for his review.

Adequate records shall be maintained in a readily retrievable manner to provide documented evidence of quality monitoring and accountability. These records shall be available to Employer at all times during the term of the Contract and during the Defects Liability Period and for a five-year period thereafter.

The Plan shall identify:

Design Process: that control, check and verify the accuracy, completeness and integration of the design shall be performed by certified personnel and in accordance with documented procedure that have the written consent of the Engineer.

Special Processes: that control or verify quality shall be performed by certified personnel and in accordance with documented procedures that have the written consent of the Engineer;

Inspection and Test: Inspection and testing instructions shall provide for reporting non-conformances or questionable conditions to the Engineer; Inspection shall occur at appropriate points in the installation sequence to ensure compliance with drawings, test specifications, process specifications, and quality standards. The Engineer shall designate, if necessary, inspection hold points into installation or inspection planning procedures;

Receiving Inspection: These procedures shall be used to preclude the use of non-conforming materials and to ensure that only correct and accepted items are used and installed;

Identification and Inspection Status: a system for identifying the progressive inspection status of equipment, materials, components, subassemblies, and assemblies as to their acceptance, rejection, or non-inspection shall be maintained;

Identification and Control of Items: an item identification and tractability control shall be provided;

Handling, Storage, and Delivery: provide for adequate work, surveillance and inspection instructions.

The Plan shall ensure that conditions adverse to quality such as failures, malfunctions,

deficiencies, deviations, and defects in materials and equipment shall be promptly identified and corrected.

The Plan shall provide for establishing, and maintaining an effective and positive system for controlling non-conforming material including procedures for the identification, segregation, and disposal of all non-conforming material. Dispositions for the use or repair of non-conforming materials shall require the Engineers consent.

1.3 Plan Implementation and Verification

The Plan shall clearly define the QA Organization. Management responsibility for the QA shall be set forth on the Contractor's policy and organization chart. The Plan shall define the requirements for QA personnel, their skills and training. Records of personnel certifications shall be maintained and monitored by the QA personnel. These records shall be made available to the Engineer for review, upon request.

The QA operations shall be subject to the Engineers, Employer or Employer's authorized representative's verification at any time, including: surveillance of the operations to determine that practices, methods and procedures of the plan are being properly applied; inspection to measure quality of items to be offered for acceptance; and audits to ensure compliance with the Contract documents.

The contractor's Quality Audit Schedule shall be submitted to the Engineer for consent every three months or more frequently as required.

The results of Quality Audits shall be summarized in the Contractor's monthly reports. The Contractor shall provide all necessary access, assistance and facilities to enable the Engineer to carry out on-site and off-site surveillance of Quality Assurance Audits to verify that the quality system which has the consent of the Engineer is being implemented fully and properly.

Annexure-4**ORGANISATION CHART AND KEY POSITIONS****Head office Organization Chart**

One Organisation chart shall be provided for the Contractor head office indicating the management and staff structure, with responsible personnel/departments described for all aspects of the work.

Site Organisation Chart

The Contractor shall provide the proposed site Organisation indicating the proposed structure, staff partners and positions necessary to adequately manage and control the Works.

The Contractor shall have a competent team of Managers, Engineers, Technical staff etc so as to complete the work satisfactorily as per various requirements of the contract.

The Key & other Positions (Personnel) not limited to and corresponding qualification and experience are as under:

Sl.No	POSITION/ DESIGNATION	QUALIFICATION	EXPERIENCE (Post Qualification) LEVEL (Minimum Requirement)	MINIMUM NUMBER REQUIRED
A	KEY POSITIONS (Personnel)			
1	Project Manager (Team Leader)	B.E/B.Tech in Civil Engineering	Minimum 15 years total experience out of which 3 years experience in the role of Project Manager or equivalent in the execution of similar nature of works	1
2	Deputy Project Manager	B.E/B.Tech in Civil Engineering	Minimum 10 years total experience out of which 3 years experience in the role of Deputy Project Manager or equivalent in the execution of similar nature of works	1
3	Launching/ Erection Expert	B.E/B.Tech in Civil/Mechanical Engineering	Minimum 8 years total experience out of which 3 years experience as Launching Expert in Similar Nature of works in the respective field i.e, Launching of Segments/Girders.	1
4	Chief Safety and Health Manager	Graduate in Engineering / MSc in Safety	Minimum 8 years of total experience and 5 years as Chief Safety and Health Manager or equivalent in Similar Nature Works	1
B	OTHER POSITIONS (Personnel)			
5	Senior Engineers	B.E/B.Tech in Civil Engineer	Minimum 7 Years of total Experience.	3
6	Construction Planning Engineers cum Quantity Surveyor	B.E/B.Tech in Civil Engineering	Minimum 5 years of total experience.	1
7	Civil Engineer	B.E/B.Tech in Civil Engineering	Minimum 5 years of total experience	5

Sl.No	POSITION/ DESIGNATION	QUALIFICATION	EXPERIENCE (Post Qualification) LEVEL (Minimum Requirement)	MINIMUM NUMBER REQUIRED
8	Quality assurance Specialist	B.E/B.Tech in Civil Engineering & Certificate/Diploma in Quality Assurance	Minimum 7 years total experience and 5 years experience in QA field out of which 1 year as incharge.	1
9	Survey Engineer	B.E/B.Tech in Civil Engineering	Minimum 5 years total experience	2
10	Safety Officer	Concerned Degree/Diploma in construction safety	Minimum 5 years experience in safety field out of which 1 year as Incharge	1
11	Mechanical Engineer	Graduation In concerned discipline	Minimum 5 years of total experience	1

NOTES:

1. The above-mentioned categories of key & other positions (Personnel) shall be minimum required for successful completion of the work which shall be deployed at different points of time as per the progress and requirement of work and may not be required to deploy simultaneously and continuously. However, these personnel shall be deployed at site in advance as per requirement and as directed by the Engineer and the decision of Engineer in this regard shall be final and binding.
2. Depending on the requirement for the completion of work within the stipulated completion period, the Contractor shall deploy additional Personnel as circumstances warrant at 'No Extra Cost'.
3. The bidder shall submit the CVs of the key positions (Sl. No.1 to 4) mentioned above along with technical proposal. Tenderer may propose any number of names of Personnel for each Key Position. Any of the proposed personnel as approved by the Employer for each key position have to be mandatorily deployed in case of award of work.
4. The bidder shall submit the CVs of the other positions (Sl. No. 5 to 11) mentioned above to Engineer for his approval within 28 days of issue of letter of Acceptance (LOA).
5. The performance of project personnel deployed will be evaluated periodically by Employer during the contract period. In case the performance of any of the project personnel is not satisfactory, the Contractor shall replace them with better or equivalent personnel immediately as per directions of the Engineer.
6. Non-deployment of the Key positions (Sl. No.1 to 4) mentioned above leads to imposition of Penalty of Rs. 2,00,000/-Per Key personnel per month and Non-deployment of the Other positions (Sl. No.5 to 11) mentioned above leads to imposition of Penalty of Rs. 30,000/- per other personnel per month.
7. The proposed Key personnel are not to be changed till the completion of the work. Under emergent circumstances, in case they are required to be changed, the new incumbent should have similar or better experience and qualification than as required above. These changes are permitted only with the approval of the Employer. Change in key personnel for one time without penalty is permitted. However, for subsequent changes there will be Penalty at 1,00,000/- per Key Personnel for Sl. No. 1 to 4.

8. All Key & other Personnel must be permanently stationed at Bangalore till the completion of the work.
9. The penalties imposed are nonrefundable.

Annexure – 5**KEY DATES****1.0 KEY DATES**

The Contractor will be required to achieve the Key Dates to be calculated from the respective 'Date of commencement of Work'. Date of commencement of work shall not be prior to the Date of Signing the Contract Agreement 'D'.

1.1 Key Dates

KD. No.	Description	Key Date (from the date of signing the 'Contract Agreement') in Months (D= Date of signing the 'Contract Agreement')
I.	SECTION (BP 503 to BP 521)	
KD-1	Mobilization of necessary resources (Manpower, materials, machinery, equipments etc.) Commencement of road widening works and setting up of casting yard including moulds for I-Girders, parapets, piling rigs etc. and laboratories with required facilities.	D+3
KD-2	Commencement of I-Girder casting and fabrication of composite girders as per specifications and drawings.	D+5
KD-3	Completion of Piles and Pile cap works etc., complete as per specifications and drawings of Span BP 503 to BP-506.	D+8
KD-4	Completion of Piles and Pile cap works etc., complete as per specifications and drawings of span BP 507 to BP 521	D+10
KD-5	Completion of Pier and Pier caps including pedestal for bearings, Portal frames (piers and pier cap) etc., complete in all respects as per specifications and drawings.	D+11
KD-6	Completion of Fabrication and Erection of Open Web Girder/Composite Girder Span as per specifications and drawings.	D+12
KD-7	Completion of casting of precast I-girders for viaducts, parapet panels, in-situ concreting of portal frames etc., complete as per specifications and drawings.	D+14
KD-8	Completion of I-Girder erection and deck slabs concreting, parapet panel fixing etc., and handing over to track contractor as per specifications and drawings.	D+15

KD-9	Completion of all the works including Road restorations as per specifications and drawings.	D+16
------	---	------

1.2 FINAL KEY DATE (ENTIRE WORK)

Key Date	Description	Key Date (from the date of signing the 'Contract Agreement') in Months D=Date of signing the 'Contract Agreement'
KD-10	Completion of entire work from BP-503 to BP-521	D+18

2.0 PENALTY FOR DELAY IN ACHIEVING KEY DATES

Key Date No.	Penalty for Delay in Achieving each Key Date
KD-1	Rs. 25,000/- (Rupees Twenty Five Thousands) per day of delay.
KD-2	Rs. 25,000/- (Rupees Twenty Five Thousands) per day of delay.
KD-3	Rs. 25,000/- (Rupees Twenty Five Thousands) per day of delay.
KD-4	Rs. 25,000/- (Rupees Twenty Five Thousands) per day of delay.
KD-5	Rs. 25,000/- (Rupees Twenty Five Thousands) per day of delay.
KD-6	Rs. 25,000/- (Rupees Twenty Five Thousands) per day of delay.
KD-7	Rs. 25,000/- (Rupees Twenty Five Thousands) per day of delay.
KD-8	Rs. 25,000/- (Rupees Twenty Five Thousands) per day of delay.
KD-9	Rs. 25,000/- (Rupees Twenty Five Thousands) per day of delay.

Note:

- 1) The Engineer will decide about completion of work regarding all Key Dates.
- 2) Any imposition of penalty on account of delay in accomplishing key dates KD-1 to KD-9 will be waived and penalty amount if deducted will be refunded (without interest), provided the contractor is able to accomplish succeeding key date /dates within the stipulated date.
- 3) These penalties shall not relieve the Contractor from his obligation to complete the works or from any other obligations and liabilities under this Contract.
- 4) "Key Dates are provisional. These will be discussed and finalized after submission of Works Programme by the successful tenderer. However, the Key date KD-10 shall remain unaltered". Any deviation from the jointly approved programme will invite penalties.
- 5) Successful tenderer is required to submit the program for approval with detailing the deployment of resources in order to achieve the Key dates within the stipulated time for completion. Until the program is approved, the Key dates mentioned above holds good and the contractor is required to achieve the Key Dates accordingly. The Penalty and incentives are applicable accordingly. Once the program is approved, the penalty for not achieving the key dates or Incentives for early completion will be recalculated.

3.0 LIQUIDATED DAMAGES FOR DELAY IN ACHIEVING KEY DATES (KD-10) AND INCENTIVE FOR EARLIER COMPLETION OF WHOLE WORK:

Key Date	Description	Duration in Months from D	Liquidated Damages (L.D)	Incentive for Early completion
KD-10	Completion of entire work from BP-503 to BP-521	D+18	One-half of one percent (0.5%) of the Contract Price for each week or part thereof for delay in achieving completion of the entire work (KD-10). Upper limit for L.D. as per General Conditions of Contract.	For early completion of the entire work as a whole within the stipulated original date of completion, an incentive of Zero Point Zero Three percent (0.03%) of Contract Price per day of early completion shall be paid to the contractor subject to a maximum of 3 % of Contract Price.

Signature of the Tenderer:

Name & Designation of Authorized signature:

Place , date and seal/stamp of the tenderer:

Annexure-6**PLANT AND EQUIPMENT**

The Contractor shall deploy minimum plant and machinery as mentioned below either owned or to be made available on hire or lease for this work as and when required.

Sl. No.	Type of Equipment required for the Work	Proposed to be deployed in Nos
1.	Fully automatic and computerized Batching and Mixing plant of capacity 30 cum/Hour or higher. OR Third party RMC from approved source.	1
2.	Mobile Cranes 60MT and above (for handling of rebars, staging materials, shutters/ frames for pier, pier caps – Average ht. of pier – min 10m)	3
3.	Crane 10 Tonnes Capacity (handling / shifting of rebars, staging materials, scaffolding materials, generators, barricading boards and other materials)	3
4.	Dozer D - 50 - A 15 (200 cum per hour)	1
5.	Front End loader (JCB) 1 cum bucket capacity	1
6.	DG sets 250 KVA	3
7.	Hydraulic Excavator of 1 cum bucket	2
8.	Paver Finisher Hydrostatic with sensor control 100 TPH	1
9.	Paver Finisher Mechanical 100 TPH	1
10.	Pneumatic Road Roller(25 cum per hour)	1
11.	Smooth Wheeled Roller 8 tone (70 cum /hour)	1
12.	Tandem Road Roller (30 cum/hour)	1
13.	Tipper - 10 cum	2
14.	Trailers for carrying precast I-girder for Viaduct	2
15.	Transit Mixer 6.0 cum or higher capacity	6
16.	Truck 20 Tonnes capacity	2

17.	Vibratory Roller 8 tonne	1
18.	Water Tanker (6000 litres capacity)	3
19.	Motor Grader 3.35 mt blade (200 cum / hour)	1
20.	Survey Equipment : Total Stations	2
21.	Survey Equipment : Auto levels	3
22.	Concrete pump, placer booms, 30 cum/hr (this item is interchangeable between locations as and when required)	2
23.	Gantries for casting yard (capacity min 15 MT + 80 MT each) for precast elements like - I girders, portal beams, Parapets etc.	2
24.	I-Girder beds along with moulds and bulk heads for viaduct	5
25.	Parapet casting moulds/shuttering for viaduct	25
26.	Hydraulic Piling rigs for 1200 mm dia piles (rigs are interchangeable to achieve target and upon work front made available to works)	3
27.	Piling rigs (Tripods)with conventional winch for 1200mm dia piles	6
28.	Launching Girders / Launching arrangements for Precast I-Girder.	2
29.	Pile cap shutters & starter for piers	4
30.	Pier, Pier cap shutters including starters for viaduct	5
31.	Dog legged staircase	5
32.	Parapet launching equipment (Gantry 20MT)	1
33.	Suitable cranes (120 tones capacity or more) as per requirement for erection of I girders.	2
34.	Crash barriers shutters	5
35.	RCC median shutters (1 set = 60m length)	1

36.	slabs shutters for casting of deck slab (in sqm) along with supporting/ staging arrangements	6000 Sqm
37.	Man lift / Boom lift of 500 kgs capacity & lift height of 60 feet	1

Note:

1. Plant and Equipment indicated above is minimum to be deployed at appropriate stage of the work. However, depending on the requirement to complete the work in the stipulated completion period, the tenderer should deploy additional machinery as circumstances warrant at no extra cost.
2. Plant and equipment to be mobilized for the work shall be in good serviceable condition.

Annexure-7
CASTING YARD

The tenderer, at his own cost, identify, establish, develop, operate, maintain and remove the casting yard(s), fabrication yard(s), reinforcement yard(s), pre-casting facilities, Project office and all associated infrastructure required for execution of the Works with the approval of the Engineer/Employer.

The scope shall include but not be limited to land arrangement unless otherwise specified in the Contract, site clearance, grading, ground improvement, internal roads, drainage, hardstanding, fencing, lighting, power supply, water supply, batching plant, casting beds, moulds, gantries, cranes, curing arrangements, storage areas, testing laboratory, workshops, labour facilities, safety arrangements, environmental protection measures, statutory approvals, watch & ward, housekeeping and all temporary works necessary for satisfactory execution of the Works.

The Contractor shall make his own assessment regarding suitability and adequacy of the casting yard for handling, casting, curing, storage and dispatch of precast elements. No additional payment shall be made on this account, and the cost shall be deemed to be included in the Contract Price. Upon completion of the Works, the Contractor shall dismantle all temporary facilities and restore the area to its original condition or as directed by the Engineer.

Annexure-8

200mm Live GAIL Gas Line

Along the full length of the alignment 200mm GAIL gas line is running live. The Contractor has to carry out all works in the presence of the existing live 200 mm dia GAIL gas pipeline with utmost care and in full compliance with all applicable safety regulations, GAIL requirements, and statutory guidelines.

The Contractor shall be fully responsible for:

- i) Protecting the existing live 200 mm GAIL gas pipeline during execution of the works. Payment will be made under the contract. Any design/ drawing preparation for arrangement, approval and execution will be the contractor's responsibility without any extra cost.
- ii) Coordinating with GAIL authorities and obtaining all necessary permissions/approvals prior to commencement of work near the pipeline.
- iii) Designing, providing, erecting, and maintaining adequate temporary/permanent support arrangements for the existing GAIL gas pipeline during construction activities. Design of temporary support system has to be approved from employer.
- iv) Ensuring that after completion and casting of the pile cap, the existing GAIL gas pipeline remains safely supported and positioned above the finished top level of the pile cap, without imposing any stress, settlement, or damage to the pipeline.
- v) Carrying out all activities without interruption to the live gas line service unless specifically approved by GAIL.
- vi) Bearing all responsibility for safety, protection, stability, and integrity of the pipeline throughout the execution period.

The Contractor shall be solely and fully responsible for the safety, protection, integrity, and uninterrupted operation of the live GAIL gas pipeline during the entire period of execution. Any damage, leakage, loss, claim, penalty, disruption, accident, or consequential loss arising out of or in connection with the Contractor's operations shall be the sole responsibility of the Contractor, who shall indemnify and keep indemnified the Employer and GAIL against all such losses, damages, claims, proceedings, costs, and liabilities.

No extra payment, claim, compensation, or additional cost whatsoever shall be entertained on account of restrictions, difficulties, safety requirements, coordination with GAIL, execution of work in the vicinity of the live gas pipeline will be paid. The quoted rates shall be deemed to include all such obligations. However, Temporary support arrangements for safety of GAIL line will be paid under item no D-38 and/or D-39 of schedule-D.

[illegible]

SECTION-I: TECHNICAL SPECIFICATIONS

Table of Contents

SECTION - I.....	2
SECTION- S.01 - GENERAL	2
SECTION- S.02 - EARTH WORK.....	22
SECTION- S.03 – STRUCTURAL CONCRETE-PLAIN,REINFORCED, PRESTRESSED.....	30
SECTION- S.04- FORM WORK.....	58
SECTION- S.05- REINFORCEMENT	69
SECTION- S.06- PRESTRESSED CONCRETE	79
SECTION- S.07- STRUCTURAL STEEL WORKS	99
SECTION- S.08 - PILE FOUNDATION	115
SECTION- S.09- ROOF SHEETING (DELETED).....	125
SECTION- S.10- OTHER WORKS- BEARING	126
SECTION- S.11- STEEL BRIDGE GIRDER ERECTION	150
SECTION- S.13- REINFORCED EARTH.....	192

SECTION - I

SECTION- S.01

1. GENERAL

1.1 General

- 1.1.1** These Specifications contained herein shall be read in conjunction with other tender documents.

Generally the work shall be carried out as per the latest edition of “Specifications for Road and Bridge works” of Ministry of Road Transport & Highways (MORTH) published by Indian Roads Congress and CPWD specifications with correction slips & amendments up to date to the extent they are applicable to the works covered under scope of works. However, the provision of MORTH specifications takes precedence over CPWD specifications. Further the specifications contained herein will supersede the provisions of the MORTH & CPWD specifications to the extent of their applicability.

- 1.1.2** The Work shall be carried out in accordance with the "Good for Construction" drawings and designs as would be submitted by the contractor and approved by the Engineer duly signed and stamped or issued to the Contractor by the Engineer duly signed and stamped by him as the case may be. The Contractor shall not take cognisance of any drawings, designs, specifications, etc. not bearing Engineer's signature and stamp. Similarly, the Contractor shall not take cognisance of instructions given by any other Authority except the instructions given by the Engineer in writing.

- 1.1.3** The work shall be executed and measured as per metric units given in the Schedule of Quantities, Drawings etc. (FPS units where indicated are for guidance only).

- 1.1.4** Absence of terms such as providing, supplying, laying, installing, fixing etc. in the descriptions does not even remotely suggest that the Contractor is absolved of such providing, supplying etc. unless an explicit stipulation is made in this contract.

- 1.1.5** The specifications have been divided into different sections / sub-heads for convenience only. They do not restrict any cross-references. The Contractor shall take into account inter-relations between various parts of works/trades. No claim shall be entertained on the basis of compartmental interpretations.

- 1.1.6** The classification of various items of works for purposes of measurements and payments shall be as per Bills of Quantities (BOQ). Except where distinguished by BOQ, the rates apply to all heights, depths, leads, lifts, sizes, shapes and locations. They also cater for all cuts and wastes. No height wise / floor wise separation shall be made for the rates. Likewise, all heights of centering, shuttering, staging, formwork and scaffolding, launching trusses and other launching methods are covered by the quoted rates including multi stage propping for heights greater than one lift / floor as per drawings.

- ### 1.1.7 Reference to the Standard Codes of Practice.

1. The contractor shall make available at site all relevant Codes of practice as applicable.

- 2 Legend:
ASCE

American Society of Civil Engineers

ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
BS	British Standard
CPWD	Central Public Works Department
DIN	Deutsches Institut für Normung e.V.
IRC	Indian Road Congress
IRS	Indian Railway Standards
IS	Indian Standards
JIS	Japanese Industrial Standard
MORTH	Ministry of Road Transport and Highways

1.1.8 Other Publications.

American Petroleum Industry (API) Standard 1104
 Indian Standard Hand Book on steel sections Part-I
 Indian Railway Manual on Design and Construction of well and pile foundations
 UIC/772-R The International Union of Railways Publication
 CIRIA Report 80 A review of instruments for gas and dust monitoring underground
 CIRIA Report 81 Tunnel Water proofing
 CIRIA Report 44 model code of practice for work in compressed air
 CIRIA Report C660 Early age thermal crack control in concrete
 CIRIA Report 91 Early age thermal crack control in concrete
 Swedish standard 05 59 00
 PCI STD-112-84
 CRR and IOC, New Delhi Bituminous Road Construction Hand Book

Alternative or additional codes and standards proposed by the contractor shall be internationally recognised codes and shall be equivalent to or better than, Indian Standards issued by the Bureau of Indian Standards or any other Indian professional body or organisation, subject to being, in the opinion of the Employer's Representative, suitable for incorporation or reference into the specifications

1.1.9 Contractor to Provide

The Contractor shall provide and maintain at site throughout the period of works the following at his own cost and without extra charge, except for the items specified in the Bill of Quantities the cost being held to be included in the Contract Rates:

1. General works such as setting out, site clearance before setting out and on completion of works. All weather approach roads to the site office should also be constructed and maintained in good condition.
2. All labour, materials, plant, equipment and temporary works, overhead charges as well as general liabilities, obligations, insurance and risks arising out of GCC, required completing and maintaining the works to the satisfaction of the Engineer.
3. Adequate lighting for night works, and also at other times whenever and wherever required by the Engineer.
4. Continuous & Rigid Temporary fences, barricades, guards, lights and protective work necessary for protection of workmen, supervisors, engineers, General public and any other persons permitted access to the site. Contractor shall provide proper signages as directed.

All fences, barricade shall be painted with colour shades as specified by the Engineer. The barricading should be of adequate height to ensure visual obstruction of work from public view.

5. All equipment, instruments, labour and materials required by the Engineer for checking alignment, levels, slopes and evenness of surfaces measurements and quality etc.
6. Design mixes and testing them as per relevant clauses of specifications giving proportion of ingredients, sources of aggregates and binder along with accompanying trial mixes. Test results to be submitted to the Engineer for his approval before adoption on works.
7. Method Statements, for each main activity of the work (temporary and permanent) to be executed detailing the purpose, scope, resources required, sequence /procedure of execution, persons responsible, time frame, safety requirements & measures, risk analysis, inspections, and Test procedures along with standard values/acceptable criteria etc. duly approved by the Engineer before start of that particular activity at site.
8. Preparation and compliance with provision of a quality assurance control program.
9. Cost of safe guarding the environment as per SCC.
10. Contractor has to provide Method statements ie detailed work procedure for all the works
11. A testing laboratory as specified by the Engineer equipped with not limited to the following apparatus, materials and competent trained staff required for carrying out tests, as specified in the relevant sections of the specifications in adequate quantity.
12.
 - (i) 1 Set of standard sieves for testing grading of sand with mechanical sieve shaker.
 - (ii) Sieves with openings respectively of 4.75mm, 10mm, 20mm, 25mm, and 30mm for testing and grading of aggregates.
 - (iii) Digital Weighing Balance of capacity up to 10 Kg. reading up to 1 gm.
 - (iv) Electric controlled oven and pans for drying of sand and aggregates.
 - (v) Glass measuring flasks ½ litre, 1 litre & 2 litre capacities.
 - (vi) Flask for determining moisture content of sand.
 - (vii) Slump cone with rod and V B Apparatus, flow table to measure slump or DIN Specifications (separate sets for laboratory and at Site).
 - (viii) Apparatus to measure permeability of concrete as per Appendix 1700/II of MORTH Specifications.
 - (ix) Sufficient Nos. steel moulds for 150mm x 150mm x 150mm concrete test cubes. It may be necessary to provide more steel cube moulds depending upon concreting programme.
 - (x) Sufficient number of 25mm dia vibrator for compaction of concrete in test cubes, vibrating table.
 - (xi) Digital Concrete cube testing machine of 200 tones Minimum capacity with direct print out facility.

- (xii) Work benches, shelves, desks, sinks and any other furniture and lighting as required by the Engineer.
- (xiii) Abrasion, Flakiness & Impact testing Equipment for testing coarse aggregates.
- (xiv) Silt Testing Equipment.
- (xv) Any other equipment specified by Engineer.
- (xvi) Permeability Testing Apparatus.

Note: All the above equipment and apparatus shall be calibrated at the time of setting up and at specified intervals by NABL accredited agency.

1.1.10 Quality Assurance & Quality Control

1. The work shall conform to high standards of design and workmanship, shall be structurally sound and aesthetically pleasing. The Contractor shall conform to the Quality standards prescribed, which shall form the backbone for the Quality Assurance and Quality Control system.
2. At the site, the Contractor shall arrange the materials, their stacking/storage as per MORTH standards to ensure the quality. The Contractor shall provide all the necessary equipment and qualified manpower to test the quality of materials, assemblies etc., as directed by the Engineer. The tests shall be conducted at specified intervals and the results of tests properly documented. The cost of all such testing shall be included in the quoted rates and nothing extra shall be paid for in this regard. In addition, the Contractor shall keep appropriate tools and equipment for checking alignments, levels, slopes and evenness of the surfaces.
3. Testing of Materials
 - (a) The Engineer shall be free to carry out such tests as may be decided by him at his sole discretion, from time to time, in addition to those specified in this document as per provisions of General Conditions of Contract. The Contractor shall provide the samples and labour for collecting the samples. Nothing extra shall be payable to the Contractor for samples, or for the collection of the samples. The test shall be conducted at the Site laboratory that may be established by the Contractor or at any other Standard Laboratory having NABL certification.
 - (b) The test shall be conducted at the Site laboratory that may (to) be established by the Contractor at his cost or at any other Standard Laboratory selected by the Engineer.
 - (c) The Contractor shall transport the samples to the laboratory for which nothing extra shall be payable. In the event of the Contractor failing to arrange transportation of the samples in proper time the Engineer shall have them transported and recover two times the actual cost from the Contractor's bills.
 - (d) All testing shall be performed in the presence of Engineer or his authorised representative. Testing may be witnessed by the Contractor or his authorised representative if permitted by the Test House. Whether witnessed by the Contractor or not, the test results shall be binding on the Contractor.
4. The Engineer shall have the right at all times to inspect all operations including the sources of materials, procurement, its transportation, layout and storage of materials, all equipment including the concrete batching and mixing equipment, and the quality

control system. Such an inspection shall be arranged and the Engineer's approval obtained prior to starting of the particular item of work. This shall however, not relieve the Contractor of his responsibilities. All materials which do not conform to these specifications shall be rejected. In the event of contractor not being able to arrange the material conforming to these specifications or in the event of failure of the contractor to get the sources approved within the agreed schedule submitted by contractor, the Engineer shall have the powers to cause the Contractors to purchase and use such materials from any particular source, as may, in the Engineer's opinion, be necessary for the proper execution of work. Nothing extra shall be payable to the contractor on this account.

1.1.11 Dimensions

1. Figured dimensions on drawings shall only be followed and drawings to a large scale shall take precedence over those to a smaller scale. Special dimensions or directions in the specifications shall supersede all others. All dimensions shall be checked on site prior to execution.
2. The dimensions where stated do not allow for waste, laps, joints, etc. but the Contractor shall provide at his own cost sufficient labour and materials to cover such waste, laps, joints, etc.
3. The levels, measurements and other information concerning the existing site as shown on the drawings are believed to be correct, but the Contractor should verify them for himself and also examine the nature of the ground as no claim or allowance whatsoever will be entertained on account of any errors or omissions in the levels or the description of the ground levels or strata turning out different from what was expected or shown on the drawings.

1.1.12 Setting out of Works

The Contractor shall set out the Works indicated in the Conditions of Contract. The Contractor shall provide suitable stones with flat tops and build the same in concrete for temporary bench marks. All the pegs for setting out the Works and fixing the levels required for the execution thereof shall, as desired by the Engineer, likewise be built in masonry at such places and in such a manner as the Engineer may direct. The Contractor shall carefully protect and preserve all bench marks and other marks used in setting out the works. The contractor will make and maintain overall layout of complete work and get it checked from engineer periodically. The cost of all operations of setting out including construction of bench marks is deemed to be included in the quoted rates as per Bill of Quantities.

- (a) All the survey work except leveling shall work shall be carried out using total stations with one second accuracy. The leveling work shall be carried out using Auto level.
- (b) The triangulation points given by Employer/Engineer before start of work shall be maintained during execution and handed over back to Employer / Engineer after completion of work.

1.1.13 Materials

1. Source of Materials

It shall be the responsibility of the contractor to procure all the materials required for construction and completion of the contract. The contractor shall indicate in writing the source of materials well in advance to the Engineer, after the award of the work and get it approved

from the Engineer before commencing the work. If the material from any source is found to be unacceptable at any time, it shall be rejected by the Engineer.

2. Quality

All materials used in the works shall be of the best quality of their respective kinds as specified herein, obtained from sources and suppliers approved by the Engineer and shall comply strictly with the tests prescribed hereafter, or where tests are not laid down in the specifications, with the requirements of the latest issues of the relevant Indian & other Standards.

3. Sampling and Testing

All materials used in the works shall be subjected to inspection and test in addition to test certificates. Samples of all materials proposed to be employed in the permanent works shall be submitted to the Engineer at least 45 days in advance for approval before they are brought to the site.

Samples provided to the Engineer for their retention are to be labeled in boxes suitable for storage. A sample room will be made at casting yard and maintained at no cost. Materials or workmanship not corresponding in character and quality with approved samples will be rejected by the Engineer.

Samples required for approval and testing must be supplied sufficiently in advance in required quantity and number to allow for testing and approval, due allowance being made for the fact that if the first samples are rejected further samples may be required. Delay to the works arising from the late submission of samples will not be acceptable as a reason for delay in completion of the works.

Materials shall be tested before leaving the manufacturer's premises, quarry or source, Materials shall also be tested at site and they may be rejected if not found suitable or in accordance with the specifications, notwithstanding the results of the tests at the manufacturer's works or elsewhere or test certificates or any approval given earlier.

The contractor will bear all expenses for sampling and testing, whether at the manufacturer's premises at source, at site or at any testing laboratory or institution as directed by the Engineer subject to the provisions of No extra payment shall be made on this account.

4. Dispatch of materials

Materials shall not be dispatched from the manufacturer's works to the site without written authority from the Engineer.

5. Test certificates

All manufacturer's certificates of test, proof sheets, etc showing that the materials have been tested in accordance with the requirement of these specifications and of the appropriate Indian Standards are to be supplied free of charge to the Engineer.

6. Rejection

Any materials that have not been found to conform to the specifications or otherwise not acceptable to the Engineer will be rejected forthwith and shall be removed from the site by the Contractor at his own cost within three days or as instructed by the Engineer.

1.1.14 Storing of Materials at site

All materials used in the works shall be stored on racks, supports, in bins, silos, go-downs, under cover etc. as appropriate to prevent deterioration or damage from any cause whatsoever to the entire satisfaction of the Engineer.

The storage of materials shall be in accordance with IS 4082 "Recommendation on stacking and storage of construction materials on site" and as per IS 7969 "Safety code for handling and storage of building materials".

The materials shall be stored in a proper manner in a place at site duly approved by the Engineer. Should the place, where material is stored by the Contractor, be required by the Employer for any other purpose, the Contractor shall forthwith remove the material from that place at his own cost and clear the place for the use of the Employer within the time as communicated by the Engineer and at no extra cost to the Employer.

1.1.15 Water

1. Water from approved source:

Potable water only shall be used for the works. Contractor shall have his own source of water duly tested and approved by Engineer. The water shall be free from any deleterious matter in solution or in suspension and be obtained from an approved source. The quality of water shall conform to IS 456.

2. Storage:

The Contractor shall make his own arrangements for storing water, if necessary, in drums or tanks or cisterns, to the approval of the Engineer. Care shall be exercised to see that water is not contaminated in any way.

Testing:

Before starting any concreting work and wherever the source of water changes, the water shall be tested for its chemical and other impurities to ascertain its suitability for use in concrete for approval of the Engineer. No water shall be used until tested and found satisfactory. Cost of all such Tests shall be borne by the contractor.

1.1.16 Workmanship

1. All works shall be true to level, plumb and square and the corners, edges and rises in all cases shall be unbroken and neat.
2. Any work not to the satisfaction of the Engineer or his representative will be rejected and the same shall be rectified, or removed and replaced with work of the required standard of workmanship at no extra cost.

1.1.17 Load Testing on Completed Structures

1.1.17.1 During the period of construction or within the defect liability period the Engineer may at his discretion order the load testing of any completed structure or any part thereof if he has reasonable doubts about the adequacy of the strength of such structure for any of the following reasons or otherwise:

- i) Results of compressive strength on concrete test cubes falling below the specified strength.

- ii) Premature removal of formwork.
- iii) Inadequate curing of concrete.
- iv) Over loading during the construction of the structure or part thereof.
- v) Carrying out concreting of any portion without prior approval of the Engineer.
- vi) Honey combed or damaged concrete which in the opinion of the Engineer is particularly weak and will affect the stability of the structure to carry the design load, more so in important or critical areas of the structure.
- vii) Any other circumstances attributable to alleged negligence of the contractor which in the opinion of the Engineer may result in the structure or any part thereof being of less than the expected strength.

1.1.17.2 All the loading tests shall be carried out by the contractor strictly in accordance with the instructions of the Engineer, as per IRS:CBC;1997 clause 18, IRC:SP-51 IS: 456, and as indicated in the Bill of quantities and as indicated hereunder. Such tests shall be carried out only after expiry of minimum 28 days or such longer period as directed by the Engineer.

1.1.17.3 In such cases the portion of the work concerned shall be taken down or cut out and reconstructed to comply with the specifications. Other remedial measures may be taken to make the structure secure at the discretion of the Engineer. However, such remedial measures shall be carried out to the complete satisfaction of the Engineer.

1.1.17.4 All costs involved in carrying out the test ordered on the grounds as mentioned in, (except load and integrity test for piles) and other incidental expense thereto shall be borne by the contractor regardless of the result of the test. In case of failure of the test the contractor shall take down or cut out and reconstruct the defective work or shall take the remedial measures, as instructed, at his own cost.

If the load testing is instructed on any ground other than mentioned in then the cost of the same shall be reimbursed if the test results are found to be satisfactory.

1.1.17.5 In addition to the above load tests, non-destructive tests on various elements such as core test and ultrasonic pulse velocity test shall be carried out by the contractor at his own expense if so desired by the Engineer. Such tests shall be carried out by an agency approved by the Engineer and shall be done using only recommended testing equipment. The acceptance criteria for these tests shall be as specified by the testing agency or good engineering practice and as approved by the Engineer.

1.2 STRUCTURAL WORK

- (a) Unless otherwise specified, only controlled concrete with design mix and weigh batching is to be used for the work.
- (b) Minimum cement content specified in MORTH Specifications-2013 (fifth revision) & CPWD specification 1996 / 2002 is purely from durability point of view. Larger content of cement shall have to be provided if demanded by mix design or as per the requirement of relevant codes.
- (c) Provision of cement slurry to create bond between plain / reinforced concrete surface and subsequent applied finishes shall not be paid extra.
- (d) Mix design using smaller aggregates of 10mm down shall also be done in advance for the use in the junction having congested reinforcement.

- (e) Procedure of mixing the admixtures shall be strictly as per the manufacturer's recommendations or as directed by the Engineer.
- (f) All the water tanks and other liquid retaining concrete structures shall undergo hydro-testing.
- (g) Special benches shall be provided at site for stacking reinforcement bars of different sizes.
- (h) Formwork for beams of RCC works shall be designed in such a way that the formwork of the adjacent slabs can be removed without disturbing the props / supports of the beams.
- (i) Wherever there are tension / suspended concrete members which are suspended from upper-level structural members, the shuttering / scaffolding of such members at lower level shall have to be kept in place till the time the upper level supporting members gain minimum required strength. Cost of such larger duration of keeping in place the shuttering / scaffolding shall be deemed to be included in the price quoted for respective structural members.
- (j) Formwork shall be provided for full height at all locations. Special precautions for such tall formwork shall be taken to ensure its safety. Extra costs for providing such formwork shall be deemed to have been included in the prices quoted against relevant items.
- (k) In the mobilization period the contractor shall carry out expeditiously and without delay the following works
 - i. Material testing and mix designs of concrete as contemplated in the specifications.
 - ii. Setting up of fully fledged site laboratory as per the requirements of these specifications.
 - iii. Any other pre-requisite items required for execution.
 - iv. Facilities at Casting yard.
 - v. Identify and get approved the source of various major construction materials.
 - vi. Setting up concrete batching and mixing plant, if required as per Employers Requirement.
 - vii. Construction of site office set up.
 - viii. Construction of labour houses etc.
- (l) Casting yard shall have following minimum facilities:
 - i. Casting beds as required.
 - ii. All handling facilities for precast elements like over gantry, etc.
 - iii. Curing arrangements as required.
 - iv. Stacking arrangements for material and precast elements.
 - v. Storing arrangement of materials.
 - vi. Proper drainage and all weather approach roads.
 - vii. All handling elements of pre cast elements
- (m) The load testing of spans/piles etc. shall be done using certified and calibrated dial gauges only. Use of levelling instruments for measuring deflections shall not be allowed

1.2.1 Supply of Monthly Progress Photographs and Album

- (a) The work covers the supply of digital color photographs (Hard copy duly annotated) along with soft copy in an album to serve as a permanent record of various stages/facets of work needed for an authentic documentation as approved by the Engineer.

(b) The photographs shall be of acceptable quality and they shall be taken by a professionally competent photographer with camera having the facility to record the date of the photographs taken in the prints and negative. The Digital camera, type and quality of photo paper shall be of standard make approved by the Engineer. Each photograph in the album shall be suitably captioned and dated.

(c) The photographs and materials including soft copy shall form a part of the records of concerned organization and prints of the same cannot be supplied to anybody else or published without the written permission.

1.2.2 Supply of Monthly Progress Video CD's

The work consists of taking video films of important activities of the works as directed by the Engineer during the currency of the Project and editing them to a video film of playing time not less than 60 minutes. It shall contain narration of the activities in English by a competent narrator. The edition of the film and script of the narration shall be approved by the Engineer.

1.2.3 Survey Work

The said work involves at the very start of work taking-over of reference point from the Engineer, establishment of control points by using DGPS double frequency and the accuracy of 1 in 50,000, triangulation points, bench marks, grid layout for all the piers and other structures maintaining horizontal and vertical control within the permissible limits, incorporating changes (if any), submission of full data in the tabulation form and survey drawings. The survey shall be including setting and layout of various works during the progress of work and matching of the station area track alignment with the alignment of the approaches at station ends and incorporating the changes (if any).

1.2.4 Barricading

The work covers barricading for the work done along the median and areas affecting road traffic. Barricading for the other areas like casting yard, batching plant, storage and other working area shall be done at own cost by the contractor. The detailed scope of work is as follows:

(i) Providing and installing the barricade of the design and type as shown in the typical sketch furnished as per the approved plan firmly to the ground and maintaining it during the progress of work.

(ii) The construction barricading / fence in general will have a width of 9.5 m (outside to outside of barricading). This can be increased or decreased at specific locations with prior approval of Engineer. The Contractor shall submit method statements for approval of Engineer demonstrating how this will be achieved at site. If required, driving of rolled section / sheet pile of suitable size into the soil shall be done to retain earth as directed by Engineer. Measurement of plan area of excavation for payment shall be permitted only up to the end of PCC under foundations if earthwork is payable separately .

(iii) Providing adequate road safety devices. A tentative list given hereunder identifies minimum items, which may be required. However, actual numbers required will be as per approved plan by the Engineer and clearance from the traffic department, Bangalore. The contractor shall not be paid extra for any addition to this list if required during the execution of works.

(iv) Dismantling of barricading and other temporary installations from the site and cleaning the site as per direction of Engineer upon completion and acceptance of work.

Tentative Road Safety Devices are mentioned below or any other safety devices as per site requirement: -

1. Supply of Red portable traffic cones of 750mm height with white reflective tape bands on 100mm width all around.
2. Hazard warning light flashes with rechargeable. Maintenance free battery & charging system.
3. Safety light island post with 11 nos. parallel reflective.
4. Red reflective arrow fitted on enabled mild steel board of 360 x 220mm size.
5. Traffic Triangular Tripod made of fluorescent cloth fitted on steel frame.
6. Retro-reflective tape (I) 50mm width.
7. Fluorescent Jackets with reflective tape all around.
8. Yellow reflective cat eyes of size 115 x 11 x 22 mm made of ABS material having 19 glass beads on each side.
9. Metal Tabular Delineator of 610mm height with reflective tapes.
10. Retro-reflective arrows diversion board 450 x 900mm with crystal clear protective transparent coat to avoid damage on 14-gauge Mild Steel sheet with and without pole.
11. Retro-reflective "Men at Work" triangular board of size 900mm with crystal protective transparent coat to avoid damage on 14-gauge Mild Steel board with and without poles.
12. Retro-reflective board for "Go Slow Work in Progress" of size 1200 x 750mm with crystal clear protective transparent coat to avoid damage to the Mild Steel board with and without pole.
13. Retro-reflective advance direction signs cum Diversion Boards of size 1200 x 900mm with crystal clear protective transparent coat to avoid damage to the 14-gauge Mild Steel sheet with and without pole.
14. Retro-reflective speed limit circular sign Boards of 600mm Diameter with crystal clear protective transparent coat to avoid damage on 14-gauge sheet (without pole).
15. 'SORRY FOR INCONVENIENCE' Retro-reflective Boards of size 900 x 300mm size with crystal clear protective transparent coat to avoid damage on 14-gauge Mild Steel sheet (without pole).
16. HAZARD MARKERS (Yellow & Black) must be put all over the construction sites. This Retro-reflective board is of size 300 x 900mm with crystal clear protective coat to avoid damage and the 14-gauge Mild Steel with or without pole.
17. 'CAUTION' tape which is normally yellow tape of special Polyether Material having 75mm width 'CAUTION' is written all over with Black colour is rolls of 300 meters.

1.2.4.1 Measurement

The barricading including all the required safety devices as listed under the above table shall be measured as per relevant item in BOQ. (Payment of the item shall be made on monthly basis over contract period including extended period, if any. The availability of maximum road width is essential requirement for smooth flow of traffic on road. Therefore, contractor may be required to shift barricading from original location to alternate location to permit smooth & free flow of road traffic. It shall be incumbent on contractor to minimize the Metro corridor (barricading space) at any point of time to facilitate free movement of road traffic. For such alternation of barricading work, no separate payment shall be admissible to contractor. Payment shall be deducted for the period during which the barricading and arrangements for traffic diversion are not satisfactory to the Engineer. The payment and deduction (if any) for the item shall be on pro-rata basis).

1.2.5 Transplantation of Trees

The item shall be carried out as per the approved plan by the Engineer after the identification of the trees to be transplanted. The actual number of trees shall be finalized after the necessary clearances by the concerned departments. The item is complete and including all expenditures for carrying out all operations i.e. excavation, watering, feeding of chemicals, back filling, lifting of trees by crane and transporting to the designated site where it is to be transplanted and all necessary care to be taken for the specified initial period till the tree gets settled at new site and up to the full satisfaction of the Engineer.

1.2.5.1 Measurement

The item shall be measured in numbers according to size of the tree as specified in the item and the full payment shall be released only when the item is executed fully as per the Scope of Work detailed out in the approved plan for transplantation of trees.

The rate shall include all required operations during the transplantation and specified duration afterwards, clearances from the concerned authorities.

1.2.6 Sub-Contractor:

Works as listed below and those dealing with proprietary materials/ products may be carried out by the Contractor through the Sub-Contractors as may be approved by the Engineer in writing. The Sub-Contractors must be firms of repute and long standing, having adequate experience and complete facilities to carry out all items of work required for completion as per Specifications and expected quality to the satisfaction of the Engineer. The Sub-Contractor must also have personnel experienced in preparing shop drawings. All such works shall be carried out under the direct supervision of the manufacturers of the proprietary materials/ products or their trained and accredited licensee.

- i. Waterproofing
- ii. Caulking & Sealants
- iii. Seismic Joints
- iv. Expansion joints
- v. Application of Silicone water repellent solution where specified.
- vi. Bearings
- vii. Painting and polishing works.

1.3 Guarantees and Maintenance:

- (i) The Contractor shall guarantee and undertake to maintain and rectify the various components of the Civil Works for their successful performance for the periods as

specified in other documents. The Contractor shall indemnify the Engineer for a similar period against any damage to property and injury to persons on account of any defective work or maintenance carried out by the Contractor. The format and text of the Guarantee and the Indemnity Bond shall be as followed in CPWD or as approved by the Engineer.

- (ii) Waterproofing for basements (which include raft, retaining walls, and expansion/separation joints in retaining walls) and roofs shall be guaranteed for 10 years. The waterproofing shall include all allied works on the roof such as concrete screed and the China Mosaic roof finish/ stone cladding on the parapet between which the waterproofing treatment shall be sandwiched.
- (iii) Waterproofing for the other areas such as toilets, kitchens, chhajjas etc. shall be guaranteed for 10 years. The waterproofing shall include all allied works on the slab etc. such as concrete/ mortar screeding, if any, floor finish between which the waterproofing treatment shall be sandwiched

1.3.1 Responsibility for Shop drawings, Samples and Mock-ups:

Approval of shop drawings, samples and mock-ups for the various components shall not absolve the Contractor of his responsibility of completing the work to the specifications, standards, tests for performance and guarantees given in these documents and to a quality of finish as desired by the Engineer.

1.3.2 Cleaning:

Surfaces on which finishes are to be provided shall be cleaned with water jets or oil free compressed air or power tools with wire brushes and detergents all as approved by the Engineer.

1.3.3 Expansion bolts/ fasteners:

- (a) Unless specified otherwise all expansion bolts/ fasteners shall be fabricated from austenitic stainless-steel sheet, strip or plate conforming to ASTM A 240 Gr 304 or bar to ASTM A 479 Gr 304 of approved make and design. The material of the bolt shall not cause any bimetallic corrosion with the reinforcing bars of the RCC/ brickwork or with any other fixings or doors or windows or skylights etc.
- (b) For steel backings the fasteners shall be prevented from contact with other metals, which would lead to bimetallic corrosion.
- (c) For brick masonry backing the sleeves of the expansion bolts shall be fixed in wedge shaped pockets having an area of 75mm x 75mm at the surface and 100mm x 100mm at the inner surface and shall be 125mm deep. The wedge could also be as a truncated cone of 75mm dia/ 100mm dia. The dimensions shall be reviewed by the Engineer during execution of the work. The wedge shall be filled with PCC 1:1:2 (1 Cement, 1 Sand and 2 Coarse Aggregate) mixed with non-Shrink Compound in the proportion as recommended by the manufacturer.
- (d) The holes drilled for the expansion fasteners shall be cleaned of all ground material, dust, etc. before inserting the expansion sleeves.
- (e) All expansion bolts fixed into soffits shall be bonded to the backing with epoxy/ polyester resin of approved make.

- (f) All expansion bolt fixings shall be tightened in accordance with the recommended torque figures by the manufacturer. Where such values are not available the Contractor shall test at least 6 samples to determine the safe torque values. All bolts shall be tightened using torque spanner/ wrenches. All bolts shall be checked 24 hours (minimum) after installation and retightened if necessary.
- (g) No walls, terraces shall be cut for making any opening after water proofing has been done without written approval of the Engineer. Cutting of waterproofing when authorized by the Engineer in writing shall be done very carefully so that no other portion of the waterproofing is damaged. On completion of the work at such places, the water proofing membrane shall be made good and ensured that the opening / cutting is made fully water proof as per specifications and details of water proofing approved by the Engineer at no extra cost. No structural member shall be cut or chased without the written permission of the Engineer.

Provision of grooves in plaster, drip courses etc, if directed, at junction of walls-ceilings, columns walls, frames-plaster and such other generally typical locations shall not be paid extra, including grooves in concrete, masonry, stonework.

1.4 Applicable Codes, Standards & Publications for Structural work

The important Codes, Standards and Publications to Contract are listed here under:

A	General
IS:875 (Part 3)	Code of practice for design loads (other than earthquake) for buildings and structures
IS:1322	Bitumen felts for water proofing and damp-proofing
IS:1893	Criteria for earthquake resistant design of structures
IS:2572	Code of Practice for construction of hollow concrete block masonry
IS:3414	Code of practice for design and installation of joints in buildings
IS:6408 (Parts 1,2)	Recommendations For Modular Co-Ordination In Building Industry - Tolerances
IS:10958	General check list of functions of joints in building
IS:11817	Classification of joints in buildings for accommodation of dimensional deviations during construction
IS:11818	Method of test for laboratory determination of air permeability of joints in buildings
IS:12440	Precast concrete stone masonry blocks
CPWD	Specifications 2009.
BS:476 (Part 7)	Method for classification of the surface spread of flame of products
BS:476 (Part 20)	Method of determination of the fire resistance of elements of construction (general principles)
BS:476 (Part 22)	Methods for determination of the fire resistance of non-load bearing elements of construction
BS:5215	Specification for one-part gun grade polysulphide-based sealants
BS:5606	Guide to accuracy in building
BS:6093	Code of practice for the design of joints and jointing in building construction
BS:8200	Code of practice for the design of non-load bearing external vertical enclosure of building

ASTM C 332	Specification for light weight aggregate for insulating concrete
SP 7	National Building Code of India
SP 23 (S&T)	Hand Book on Concrete Mixes
B	Bitumen
IS:702	Industrial Bitumen
IS:3384	Specification for bitumen primer for use in waterproofing and damp-proofing
C	Building Construction Practices
IS:1838 Parts I and II.	Specifications for preformed fillers for expansion joint in concrete pavements and structures.
IS:1946	Code of Practice for use of fixing devices in walls, ceilings, and floors of solid construction.
IS:6509	Code of Practice for installation of joints in concrete pavements.
IS:11134	Code of Practice for setting out of buildings.
IS:11433	Parts I and II. Specifications for one part Gun grade polysulphide based joint sealant.
IS:12200	Code of Practice for provision of water stops at transverse contraction joints in masonry and concrete dams
D	Cement
IS:269	33 grade ordinary Portland cement
IS:455	Portland Slag Cement
IS:650	Specification for standard sand for testing cement.
IS:1489 (Part 1)	Portland pozzolana cement: Flyash based
IS:1489 (Part 2)	Portland pozzolana cement: Calcined clay based
IS:3535	Method of Sampling Hydraulic Cements
IS:4031	(Parts 1 to 15) Methods of physical tests for hydraulic cement.
IS:4032	Method of chemical analysis of hydraulic cement.
IS:6925	Methods of test for determination of water soluble chlorides in concrete admixtures.
IS:8042	White Portland Cement
IS:8112	Specification for 43 grade ordinary Portland cement.
IS:12269	Specification for 53 grade ordinary Portland cement.
IS:12330	Specification for sulphate resistant Portland cement.
E	Concrete
IS:456	Code of practice for plain and reinforced concrete.
IS:457	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.
IS:460 (Parts I to III)	Specification for Test Sieves
IS:516	Methods of test for strength of concrete.
IS:1199	Methods of sampling & analysis of concrete.
IS:1200	Method of measurement of building and civil engineering works (Parts 1 to 15)
IS:1343	Code of practice for prestressed concrete
IS:1607	Method of Test Sieving
IS:2386	Parts I-VIII. Methods of tests for aggregates for concrete.

IS:2430	Methods of Sampling of Aggregates of Concrete
IS:2438	Specification for roller pan mixer
IS:2514	Specification for concrete vibrating tables
IS:2571	Code of practice for laying in-situ cement concrete flooring
IS:2645	Specifications for integral water proofing compounds for cement mortar and concrete
IS:2722	Specifications for portable swing weigh batchers for concrete (single and double bucket type)
IS:2770	Methods of testing bond in reinforced concrete part I pull out test
IS:3025	Methods of sampling and tests (physical and chemical) for water & waste water (Parts 1 to 14)
IS:3370	Code of practice for concrete structures for storage of liquids
IS:3935.	Code of practice for composite construction
IS:4326	Code of practice for earthquake resistant construction of building
IS:6925.	Methods of test for determination of water soluble chlorides in concrete Admixtures
IS:7242	Specifications for concrete spreaders
IS:7251	Specifications for concrete finishers
IS:7861	Parts I & II. Code of practice for extreme weather concreting.
IS:7969	Safety code for handling and storage of building materials
IS:8989	Safety code for erection of concrete framed structures
IS:8142	Methods of test for determining setting time of concrete by penetration resistance
IS:9103	Specifications for admixtures for concrete
IS:9013	Method of making, curing and determining compressive strengths of accelerated cured concrete test specimens
IS:9284	Method of test for abrasion resistance of concrete
IS:10262	Recommended guidelines for concrete mix design.
MORTH	Specifications for Road and Bridge Works, Ministry of Road Transport and Highways (Roads Wing)
IRS	Concrete Bridge Codes
IRC -112-2011	Concrete Bridge Codes
ASTM - C - 94	Ready Mix Concrete
IS 4926:2003	Ready Mixed Concrete – Code of Practice
ASTM – C - 1240	Specifications for Silica Fume for use in Hydraulic Cement and Mortar
F	Construction Plant and Machinery.
IS:1791	Specification for batch type concrete mixers.
IS:2505	General requirements for concrete vibrators: Immersion type.
IS:2506	General requirements for screed board concrete vibrators.
IS:3558	Code of Practice for use of immersion vibrators for consolidating concrete.
IS:4925	Specification for concrete batching and mixing plant.
IS:11993	Code of Practice for use of screed board concrete vibrators.
IS-3366	Specifictaion for Pan vibrations
IS-4656	Specifictaion for form vibrations

G	Formwork
IS:4990	Specifications for plywood for concrete shuttering work.
IRC:87	Guidelines for the design and erection of false work for road bridges.
IS:806	Code of practice for use of steel tubes in general building construction.
IS:1161	Specification of steel tubes for structural purposes.
IS:1239	Specification for mild steel tubes. Tubulars and other wrought steel fittings.
H	Gypsum and Gypsum Board
IS:2095	Gypsum plaster boards
IS:2542 (Part 1/Sec 1 to 12)	Methods of test for gypsum plaster, concrete and products: plaster and concrete
IS:2542 (Part 2/Sec 1 to 8)	Methods of test for gypsum plaster, concrete and products: Gypsum products
IS:2547 (Part 1)	Gypsum building plaster: Excluding premixed lightweight plaster
IS:2547 (Part 2)	Gypsum building plaster: Premixed lightweight plaster
I	Handling and Storage
IS:4082	Recommendation of Stacking and Storage of construction materials
IS:8348	Code of practice for stacking and packing of stone slabs for transportation
J	Instruments For Testing Cement and Concrete
IS:5513	Specification for vicat apparatus.
IS:5514	Specification for apparatus used in Le-Chaterlier test.
IS:5515	Specification for compaction factor apparatus.
IS:7320	Specification for concrete slump test apparatus.
IS:7325	Specification for apparatus to determine constituents of fresh concrete.
IS:10080	Specification for vibration machine.
IS:10086	Specification for moulds for use in tests of cement and concrete.
IS:10510	Specification for vee-bee consistometer.
K	Joint Fillers
IS:1838 (Part 1)	Preformed fillers for expansion joint in concrete pavements and structures (non extruding and resilient type): Bitumen impregnated fiber
L	Paints and Coatings
IS:109	Ready mixed paint, brushing, priming, plaster, to Indian Standard Colour No. 361 and 631 white and off white.
IS:347	Varnish, shellac, for general purpose.
IS:2074	Ready mixed paint, air drying, red oxide-zinc chrome, priming
BS:6496	Specification for powder organic coatings for application and stoving to aluminium alloy extrusions, sheet and preformed sections for external architectural purposes, and for the finish on aluminium alloy extrusions, sheet and preformed sections coated with powder organic coatings

BS:EN:10152	Specification for electrolytically zinc coated cold rolled steel flat products. Technical delivery conditions
ASTM A 164-71	Specification for electrodeposited coatings of zinc on steel
IS 102	Ready mix paint, brushing red lead non sealing
M	Pigment for Cement
BS:1014	Specification for pigments for Portland cement and Portland cement products
N	Reinforcement & Structural Steel
IS:280	Mild steel wire for general engineering purposes
IS:432	Part I. Mild steel and medium tensile steel bars. Part II Hard drawn steel wire.
IS:815	Parts I & II. Electrodes for metal arc welding of structural steel.
IS:816	Code of Practice for use of metal arc welding for general construction in mild steel.
IS:1566	(Part I) Specifications for hard-drawn steel wire fabric for concrete reinforcement.
IS:1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.
IS:2502	Code of Practice for bending and fixing of bars for concrete reinforcement.
IS:2629	Recommended practice for hot-dip galvanising of iron and steel.
IS:2751	Code of Practice for welding of mild steel plain and deformed bars for reinforced concrete construction.
IS:4759	Hot-dip zinc coating on structural steel and other allied products.
IS:5525	Recommendations for detailing of reinforcement in reinforced concrete works
IS:9417	Recommendations for welding cold-worked steel bars for reinforced concrete construction.
IS:14268	Uncoated stress relieved low relaxation steel class 2 for Pre-stressed concrete
IS:226	Structural steel (Standard Quality)
IS:800	Code of practice for use of structural steel in general building construction.
IS:813	Scheme of symbols for welding.
IS:814	Covered electrodes for metal arc welding of structural steel. (Part I & Part II)
IS:816	Code of practice for use of metal arc welding for general construction in mild steel.
IS:822	Code of practice for inspection of welds.
IS:1024	Code of practice for use of welding in bridges and structures subject to dynamic loading.
IS:1161	Steel tubes for structural purposes.
IS:1182	Recommended practice for radiographic examination of fusion welded butt joints in steel plates.
IS:2062	Structural steel
IS:3757	Specification for high strength structural bolts.
IS:5624	Specification for foundation bolts.
IS:3600	Code of practice for testing of fusion welded (Part I) joints and weld metal in steel.

IS:4923	Hollow steel sections for structural use.
IS:801	Code of practice for use of cold formed light gauge steel structural members in general building construction.
IS:811	Specifications for cold formed light gauge structural steel sections.
IS:8910	General requirements steel products
IS:9595	Recommendations for metal arc welding of carbon & Carbon-Manganese steels
IS:7205	Safety Code for erection of Structural Steel Works
O	Aggregates
IS:383	Coarse and fine aggregates from natural sources for concrete.
P	Scaffolding
IS:2750	Specification for steel scaffoldings
IS:3696 (Part 1)	Safety Code of scaffolds and ladders: Scaffolds
IS:3696 (Part 2)	Safety Code of scaffolds and ladders: Ladders
IS:4014 (Part 1)	Code of practice for steel tubular scaffolding: Definition and materials
IS:4014 (Part 2)	Code of practice for steel tubular scaffolding: Safety regulations for scaffolding
IRC:87	Guidelines for the design and erection of falsework for road bridges
Q	Sealants
IS:10959	Glossary of terms for sealants for building purposes
IS:11433 (Part 1)	One part gun- grade polysulphide based joints sealants: General requirements
IS:11433 (Part 2)	One part gun- grade polysulphide based joint sealants: Methods of test
IS:13055	Methods of sampling and test for anaerobic adhesives and sealants
BS:5889	Specification for one part gun grade silicone-based sealants.
R	Wood
IS:303	Plywood for General Purposes
IS:848	Synthetic resin adhesives for plywood (phenolic and aminoplastic)
IS:1141	Seasoning of Timber - Code of Practice
IS:1328	Veneered decorative plywood
IS:1659	Block Boards
IS:2046	Decorative thermosetting synthetic resin bonded laminated sheets
IS:2202 (Part 1)	Wooden flush door shutters (solid core type): Plywood face panels
IS:2202 (Part 2)	Wooden flush door shutters (solid core (type): Particle face panels and hardboard face panels

S IRC:83Part-II IRC:83 Part-III	Bearings Standard specifications and code of practice for road bridges Elastomeric Bearings Standard specifications and code of practice for road bridges Pot Bearings Standard specifications and code of practice Spherical Bearings for road bridges
T IS 4985	UPVC Pipe for Drainage Unplasticized PVC Pipes for portable water supplies
U IS :2911 PART-I IRC:78	PILING Bored Cast in-situ Concrete Piles Standard specifications and code of practice for road bridges Foundation And Substructure
IS : 3764	Code of safety for excavation work
	RDSO guidelines and Bridge manual
V	All Indian Railway Standards
W	MORT&H Specifications for Road and Bridge works (latest Revision)
X	CPWD Specifications (latest Revision)

SECTION- S.02

2. EARTHWORK

2.1 Excavation

Site Clearance

The Contractor shall clear the Site as required by demolishing and removing vegetation, debris, trees along with their roots, buildings etc. and the like to approved locations either on or off the site as agreed by the Employer's Representative.

Stumps and major roots shall be grubbed up and disposed of off the site or burnt as directed. The Contractor shall take precautions to prevent the spread of fire to adjacent areas.

Top Soil Stripping

Top soil shall be removed as required, deposited in separate heaps at locations approved by Employer's Representative.

Removal of Unsuitable Material

The Contractor shall remove unsuitable material as ordered or agreed by the Employer's Representative and shall dispose of it on or off the site as directed in the required manner. Boulders, stones and other materials of value or usable again on the works shall be neatly stacked and graded as directed by Employer's Representative.

Excavation – General- (soil and rock)

- (1) Excavation shall be carried out to the lines, levels and profiles shown on the Drawings. The work shall be carried out by the Contractor in such a way as to avoid soil erosion, ground water pollution, accidents in habitational or frequented places, disturbance to the surrounding ground or structures, accident to workmen and any other untoward incident. Particular care shall be taken to maintain stability when excavating in close proximity to existing works. Fencing, caution signages with red lights and other safety measures shall be employed to avoid accidents. Where necessary, signal men shall be employed to guide the movement of people, vehicles and equipment.
- (2) The work shall be carried out in a careful manner to ensure that the exposed surfaces are as sound as the nature of the material permits and that no point shall protrude inside the lines shown on the Drawings except as otherwise specified or agreed by the Employer's Representative. In soft soil excavation which is to remain open permanently, exposed faces shall be formed accurately to the required slopes and profiles and properly protected by turfing or pitching as required by Employer's Representative.
- (3) The Contractor shall dispose of all material arising from excavations either off the site or to approved tips on the site, as required.
- (4) The Contractor shall be responsible for keeping all excavations free from water from whatever cause arising and shall provide such pumping capacity and other measures as may be necessary for this purpose.

- (5) The Contractor shall properly support the sides of excavations and shall be responsible for their safety. In case of any slips or blows in the excavation, the same shall be cleared by the Contractor at his own cost.
- (6) The Contractor shall notify the Employer's Representative without delay of any permeable strata, joints, faults, fissures or unusual ground conditions encountered during excavation.
- (7) The contractor shall ensure that no air pollution takes place during excavation, storage and transportation of earth by providing suitable measures like cover etc.
- (8) The Contractor shall provide to the Employer's Representative full details of the proposed rock excavation methods for his approval. Excavation should be carried out by such manual/mechanical means or methods, so as to eliminate noise and dust upto the prescribed limits and without using any blasting and/ or any expansive chemicals. Similarly, the Contractor shall submit his plans for methods for monitoring vibration adjacent to residential area.
- (9) The Contractor shall carry out rock stabilisation measures with minimum delay after the excavation of each round. In order to facilitate this, the Contractor shall request that the Employer's Representative always accompanies him when inspecting the existing structures and excavated rock surfaces revealed after excavation operations.

Excavation beyond True Lines and Levels

If from any cause whatsoever excavations are carried out beyond their true line and level other than as per existing approved drawings then the Contractor shall make good at his own cost to the required line and level with the appropriate grade of filling and compaction to be contained in the true excavation, or with concrete or other approved material in such a manner as the Employer's Representative shall require.

Approval of Excavation

When excavations have been taken out accurately to the profiles or dimensions required for the work, the Contractor shall inform the Employer's Representative so that he may carry out an inspection.

If, after his inspection the Employer's Representative requires additional excavation to be carried out, the Contractor shall do so to such new profiles or dimensions as the Employer's Representative may direct.

Excavations for Structures

- (1) Open excavation to lay a foundation for a structure shall be carried out to the lines and dimensions necessary to permit the proper construction of the structure.
- (2) Where a structure is to be founded on soft ground, the excavation shall be taken down until the required suitable soil formation is exposed and prepared to the satisfaction of the Employer's Representative.
- (3) If required, before any concrete for a foundation is placed, the bottom of the excavation shall be re-compacted to achieve a dense smooth and level surface both longitudinally and transversely or stepped. Subject to the satisfaction of the Employer's Representative, sand layers not exceeding 150 mm thick shall be placed and compacted to 95% of the maximum dry density over the same.

- (4) In the event of excavation having been made deeper than that shown on the drawings or as ordered by the Employer's Representative, the extra depth shall be made up with concrete or masonry of the foundation grade at the cost of the contractor. Ordinary filling shall not be used for the purpose to bring the base of foundation to required level.
- (5) Surfaces of excavations or filling which are to receive reinforced concrete work shall, where indicated, be prepared with a binding layer of concrete as shown on the Drawings or in such other manner as will provide a suitable surface at the correct lines and levels to the satisfaction of the Employer's Representative.
- (6) The last 200 mm depth of excavation shall be done not earlier than 36 hours before laying the evelling course below foundations.

Trench Excavation

- (1) Trench excavation shall be performed by the use of suitable hand tools or mechanical equipment, in such manner as to minimize disturbance of the sides and bottom of the excavation.
- (2) Trenches for pipes shall be excavated to a sufficient depth and width to enable the pipe and the specified joint, bedding, haunching and surrounding to be accommodated.

Trenches

- 1) The Contractor shall carry out excavation in a safe manner such that the sides of the trench are adequately supported and stable till the completion of work.
- 2) The Contractor shall leave a clear adequate space between the edge of the excavation and the inner toes of the spoil banks.
- 3) Trenches shall be excavated to the lines and levels shown on the Drawings.
- 4) Trenches shall not be excavated too far in advance of pipe laying and shall be sufficiently wide to allow proper and efficient jointing to be carried out in clean and dry conditions. Due allowance shall be made for bedding and surrounds where these are specified.
- 5) The bottoms of all trenches shall be trimmed to grade and level and compacted before any bedding is placed or pipes are laid.
- 6) The widths of trenches crossing roads or at other locations as directed shall be as narrow as is practicably possible. The maximum width measured between undisturbed soil in the trench sides shall not exceed the outside diameter of the pipe being laid plus 550 mm for pipes up to and including 800 mm in diameter and plus 750 mm for pipes over 800 mm in diameter. The depth of excavation shall be such as to provide adequate cover / cushion to the pipe.
- 7) Trenches for pipes carrying water under pressure shall, except where otherwise described in the Contract, be excavated to a sufficient depth to ensure a minimum cover of 900mm to the top of the pipes.

Road Crossings

The Contractor shall provide the excavated portion with sheeting/shoring to adequately support all trenches across existing roads. Great care shall be taken by the Contractor to ensure that existing roads and services are not damaged by road crossing operations. The trenches on

roads shall be back filled and roads repaired as per grade and compaction on utmost priority taking all safety precautions.

Channels

- (1) Channels shall be excavated by methods which do not endanger the stability of the side slopes.
- (2) Existing channels, which are to be reshaped, cleared and trimmed, shall be cleared of all weeds and growth and the beds graded to the required levels. The sides of channels shall be trimmed to the required safe limits of slope and width.
- (3) Side banks of channels shall be trimmed to a neat appearance and even surfaces.
- (4) Any channels, streams, drains or pipes taking water to or from cultivated land shall be diverted so as to maintain their flow before being moved or broken into. All diversions and their subsequent reinstatement shall be carried out to the satisfaction of the Employer's Representative.
- (5) The Contractor shall control the rates of filling and draw-down of water in channels so as not to endanger the stability of earthworks.

Approval of Excavations prior to Backfilling

The Contractor shall obtain approval of excavations prior to placing pavement layers, fill or concrete. The Contractor shall maintain open excavations in an approved condition, and shall rectify the effects of deterioration due to weather.

2.2 Fill

Fill – General

Prior to commencement of filling, the Contractor shall submit in writing to the Employer's Representative for 'Notice of No Objection' his proposals for carrying out the work such that the optimum use may be made of excavated material. The proposals shall include details of the compaction plant and methods for adjusting the moisture content of the material. Filling shall not commence until the 'Notice of No Objection' proposals and the material intended to be used are put up for review by the Employer's Representative and finally his observations are carried out.

Fill Material

Fill material, other than for roadworks, shall be evenly graded granular material. Material with more than 20% passing a 75micron sieve or more than 10% in excess of 75 mm size is unlikely to be suitable for use. Clods or hard lumps of earth over 75 mm in greatest dimension shall be broken up before compacting the material in embankment.

Following types of material are considered unsuitable and shall not be used for fill or embankment:

- a. Materials brought from swamps, marshes or bogs;
- b. Peat, loam, fine silt, log, stump or organic or perishable materials;
- c. Material susceptible to spontaneous combustion;
- d. Clay of liquid limit exceeding 80 and plasticity index exceeding 55;
- e. Materials containing salts prone to inducing leaching in the embankment.

The Contractor shall carry out the following initial tests on the proposed material

- 1) Wet sieve analysis
- 2) Dry density/moisture content relationship

Thereafter, one set of tests shall be carried out for each 2000 cum of fill, supplied to Site or as required by Employer's Representative.

Fill material shall be obtained only from the approved source.

Backfill – General

Except around structures, excavations shall be backfilled with suitable excavated material and/or approved material compacted in layers of 300 mm maximum thickness to achieve a density of at least 92% of the maximum dry density in non-motorable areas and 98% in motorable areas.

Backfill to Structures

The Contractor shall not backfill around structures until the structural elements have attained adequate strength and the consent of the Employer's Representative to proceed for type of fill material has been obtained. Unless otherwise directed, the backfill material shall be selected excavated material or sand, thoroughly compacted in layers not exceeding 200 mm deep to achieve a density of at least 95% of the maximum dry density.

Preparation of Base/ Foundation for Embankment

- (a) Prior to placing any embankment upon any area all clearing and grubbing operations shall have been completed in accordance with Clause 2.1. and got approved by the Engineer's Representative for starting of filling operations. Where the height of embankment is 1 meter or less all sod, grass and vegetable matter shall be removed from the ground surface and the top 15 centimeters shall be processed as necessary and compacted to 92% of the maximum dry density in non-motorable areas and 98% in motorable areas.
- (b) Where embankments are to be constructed on slopes, the existing slopes shall be loosened by scarifying or ploughing to a depth of not less than 10 centimeters, to ensure a good bond between the embankment and the embankment foundation, or where this is impracticable, steps in vertical and horizontal face shall be cut in the existing slope and the embankment built up in successive layers. Material which has been loosened shall be recompacted simultaneously with the first level of embankment material placed.
- (c) Where an embankment is to be placed against sloping ground, having slopes steeper than 4 horizontals to 1 vertical, continuous horizontal benches, each at least 300 mm wide, shall be cut in to the old slope for ensuring adequate bond with fresh embankment being added.
- (d) Where existing embankments are to be widened or included in new embankment, the slopes of the exiting embankment shall be ploughed or scarified to a depth of not less than 10 centimetre or, where this is impracticable, steps in horizontal and vertical faces shall be cut in existing slopes and the embankment built up in successive layers to the level of the old road, before its height is increased.

Unless otherwise shown on the Drawings, where existing unpaved roads are to be covered with less than 30 centimeters of fill, excluding pavement, the top of the old road bed shall be scarified and recompacted with the next layer of the new embankment. The total depth of the scarified and added material shall not exceed the permissible depth of Layer.

- (e) Embankments in swamps or water shall be constructed by sand embankment. The Contractor shall excavate or displace swamp ground and backfill with suitable material. Backfill will be in accordance with the same provisions as for embankment.
- (f) Fill material shall not be placed against any abutment or wing wall unless permission has been granted by the Employer's Representative.

Placing Embankment

Embankment shall be placed in accordance with the following requirements:

(a) General:

Except as otherwise required all embankments shall be constructed in layers approximately parallel to the finished grade of the track/ road bed. During construction of embankment, a smooth grade having an adequate crown or superelevation shall be maintained to provide drainage. Embankments shall be constructed to the required grade, and completed embankments shall correspond to the shape of the typical sections as shown on the Drawings.

During construction of embankment, it should be ensured that any work, which is to be done during the course of laying the fill material shall not be left out.

(b) Earth Embankment:

Earth embankments shall be defined as those principally of material other than rock, and shall be constructed of approved material brought from designated or other approved sources.

Except as specified for embankment in swamps, earth embankments shall be constructed in successive layers, for the full width of the cross section and in such lengths as are suited to the compaction and watering methods used.

(c) Placing over swamp ground:

Embankment in or over swamps or in water shall be placed by dumping sand in a uniformly distributed layer of a thickness not greater than that necessary to support the equipment while placing subsequent layers, after which the remainder of the embankment should be constructed in layers and compacted as specified.

(d) Preparation of subgrade:

The surface of the finished subgrade shall be neat and workmanlike and shall have the required form, super elevation, levels, grades, and cross section. The surface shall be constructed to sufficient accuracy to permit the construction of subsequent layers of material to the thickness, surface tolerance, and compaction specified.

Compaction of Embankments

- (a) When necessary, each layer, before being compacted, shall be processed as required to bring the moisture content sufficiently close to optimum to make possible its compaction to the required density. The material shall be worked as to have uniform moisture content through the entire layer.
- (b) Each layer of material shall be compacted uniformly by use of adequate and appropriate compaction equipment. The compaction shall be done in a longitudinal direction along

the embankment and shall generally being at the outer edges and progress towards the centre in such a manner that each section receives equal compactive effort.

Hauling equipment shall be operated over the full width of each layer in so far as practicable. There should be a minimum overlap of 150 mm between each run of the rollers.

- (c) Embankment or backfill compaction shall be carried out in one of the following two ways:
- Either the top 15 centimeters of the finished embankment shall be compacted to a dry density equal to at least 95% of the maximum dry density. Other embankment layers more than 15 centimeters below finished surface or the underside of the lowest layer of base sub-base and shoulder shall be compacted to a dry density equal to at least 90% of the maximum dry density.

OR the embankment shall be compacted to a dry density equal to at least 95% of the maximum dry density. In the case of embankment exceeding 70 cm in height, layers more than 50 cm below finished surface or the underside of the lowest layer of base sub-base and shoulder shall be compacted to a dry density equal to at least 90% of the maximum dry density. The method to be adopted shall be directed by Employer's Representative.

Inverted Filter

An inverted filter consisting of stone boulders and coarse aggregates to accepted grading shall be constructed behind the earth retaining structures up to the height as shown in the drawings.

It shall be constructed simultaneously with the filling work. Care shall be taken during laying of filter media that it does not cause damage to structural members or application of excessive pressure against the structure.

Tests

Testing of Fill – General

Classification tests as per relevant Standards to which the Engineer's Representative has given his consent shall be carried out to ensure that true comparisons can be made between in-situ densities, laboratory compaction densities and field trial densities i.e. that variations in properties of materials being used in the tests are not affecting the results.

Tests shall be carried out on fill to determine the degree of compaction achieved, at the rate of one test for either each 1,200 cum or each layer whichever is more frequent. Compacted layers shall not be covered without approval.

The density of individual compacted layers shall be determined by a method acceptable to the Engineer's Representative.

The in-situ dry density of fill shall average 95% of the maximum reached in trials. No single result shall be less than 92% and no more than 25% of the results on any one layer shall fall between 92% and 95%. The average shall be computed from the total number of tests on any one layer where the extent of the layer is defined by the Contractor in submitting same for inspection.

Materials for Top Layer of Fill

In addition to the general requirements for fill material, the material in the top layer shall not exceed the following test values:

Plasticity Index: 6

Liquid Limit: 35

Total fine shall not exceed 15%,

Uniformity Coefficient (Cu) shall not be less than 4.

The laboratory California Bearing Ratio (CBR) value, at 95% of the maximum dry density achieved after soaking for 96 hours, shall not be less than 30%.

Testing of Top Layer

Tests shall be carried out on the top layer of fill as follows:

Test	Frequency of test (not less than one test per)
A. Laboratory tests to monitor the consistency of the approved material during construction:	
Maximum dry density	1500 sqm
Optimum moisture content	1500 sqm
Grading	1500 sqm
Plasticity index	1500 sqm
Linear shrinkage	1500 sqm
CBR Value	3500 sqm
B. In situ tests to confirm that the required degree of compaction is being achieved during construction	
Dry density	500 sqm
CBR Value	2500 sqm

Tests shall be Test shall be carried out as required by the accepted test procedures.

SECTION- S.03

3. STRUCTURAL CONCRETE: PLAIN, REINFORCED & PRESTRESSED

These specifications shall be read in conjunction with the IRS Concrete Bridge Code, IS 456, MORTH and CPWD specifications 2013/2009 with correction slips / amendments upto date, and other relevant specifications described in the Section 1 of these Specifications.

3.1 Materials

Before bringing to the site, all materials for concrete including their source shall be approved by the Engineer. All approved samples shall be deposited in the office of the Engineer before placing orders for the materials with suppliers. The materials brought on to the works shall conform in every respect to the approved samples.

In case of change in type and/or source of any approved material, the contractor shall inform the Engineer and Fresh samples shall be deposited with Engineer whenever type or source of any material changes. The contractor shall check fresh consignment of materials as it is brought on to the works to ensure that they conform to the specifications and/or approved samples.

The Engineer shall have the option to have any of the materials tested at any time to find out whether they are in accordance with specifications at the contractor's expense. All bills vouchers and test certificates which in the opinion of the Engineer are necessary to convince him as to the quality of materials or their suitability shall be produced for his inspection when required.

If fly ash is used in concrete, the contractor shall demonstrate the quality control procedure including source of fly ash, its properties, handling as per the relevant IS & international codes etc. and shall use in slabs and walls only after "no objection" to the same has been obtained from the Engineer.

Any material which has not been found to conform to the specifications and not approved by the Engineer shall be rejected forthwith and shall be removed from the site by the contractor at his own cost within the time stipulated by the Engineer. In the event of contractor not being able to arrange the material conforming to specifications or in the event of failure of the contractor to get the sources approved within the agreed schedule submitted by contractor, the Engineer shall have the powers to cause the Contractors to purchase and use such materials from any particular source, as may, in the Engineer's opinion, be necessary for the proper execution of work. Nothing extra shall be payable to the contractor on this account.

Contractor shall also ensure that all constituents of exposed concrete shall be taken from same sources to achieve a uniform color and texture.

3.1.1 Cement

3.1.1.1 The cement used shall be of the following types:

43 grade Ordinary Portland Cement conforming to IS: 269-2015 for RCC & PCC works.
53 grade Ordinary Portland Cement conforming to IS: 269-2015 for RCC & PSC works.
IRST-40 Indian Railway standard specifications for special grade cement for use in concrete sleepers

For piling and foundation work, type of cement shall be as mentioned in section S-08 on Pile Foundations herein.

'Cement' means Ordinary Portland Cement conforming to IS 269 or slag cement conforming to IS 455 excluding mineral admixture/ additions as mentioned in para 5.2 of IS 456.

3.1.1.2 Whenever possible all cements of each type shall be obtained from one constant source throughout the contract. Cement of different types shall not be mixed together. Different brands of cement, or the same brand of cement from different sources, shall not be used without prior approval of the Engineer.

3.1.1.3 Packaged cement shall be delivered to the site in original sealed bags which shall be labeled with the weight, name of manufacturer, brand, date of Manufacture and type. Cement received in tor bags shall not be used. Cement shall be used in the order in which it is received. Cement in bags in storage for more than 3 months shall be retested before use. A sample taken once for every 1000 bags shall be tested.

Contractor may obtain cement in bulk and store it in suitable silos of adequate capacity. Each type of cement shall be stored in a separate silo and it shall be ensured, that cements of different quality are not mixed up.

3.1.1.4 All cement shall be fresh when delivered and at ambient atmospheric temperature.

3.1.1.5 In fair faced elements, the cement used in the concrete for any complete element shall be from a single consignment. All cement for exposed concrete shall be from the same approved source and uniform in colour.

3.1.1.6 With each and every delivery of cement consignment, the contractor shall provide manufacturer's certificate that the cement conforms to the relevant Indian standard. The contractor shall provide complete facilities at site for carrying out the following tests:

- (a) Setting time by Vicat's apparatus as per IS: 4031 and IS: 5513.
- (b) Compressive strength of cement as per IS: 4031, IS: 650, IS: 10080.

3.1.1.7 Total chloride content in cement shall in no case exceed 0.05 percent by mass of cement. Also, total Sulphur content calculated as sulphuric anhydride (SO₃), shall in no case exceed 2.5 percent and 3.0 percent when tri-calcium aluminate per cent by mass is upto 5% or greater than 5% respectively.

3.1.2 Aggregates

Aggregates from natural sources shall be in accordance with IS: 383. The contractor shall submit to the Engineer certificates of grading and compliance for all consignments of aggregate. In addition, at site from time to time, the contractor shall allow for carrying out such tests and for supplying test records to the Engineer. The aggregates shall be procured from approved sources only as directed by the Engineer from time to time.

For fair faced concrete, the contractor shall ensure that aggregates are free from iron pyrites and impurities, which may cause discoloration. Aggregates shall be stored on paved areas in different compartments according to their nominal size.

3.1.2.1 Fine Aggregates

The contractor shall provide complete facilities at site for determining grading of aggregates by sieves as per IS: 383, IS: 460, IS: 1607, and IS: 2386. The fine aggregate

shall be river sand pit sand, stone dust or other approved sand. It shall be free from clay, loam, earth or vegetable matter, salt or other harmful chemical impurities. It shall be clean, sharp, strong, angular and composed of hard siliceous material. If considered by the Engineer as necessary, the sand shall be washed in screw type mechanical washers in potable water to remove silt, clay and chlorides. This shall be done at least one day before using it in concrete. The washed sand shall be stored on a sloping concrete platform and in such a manner as to avoid contamination. Such sand washing, storing, etc. shall be at the Contractor's cost. The grading of fine aggregate when determined as described in IS: 2386 (part I), shall be within the grading zones I, II, III.

Water absorption shall be less than 3% by weight (ASTM C 117)

The contractor shall provide complete facilities at site for carrying out the following tests:

- A) Proportion of clay, silt and fine dust by sedimentation method as per IS:2386 part II.
- B) Moisture content in fine aggregate as per IS: 2386 Part III.
- C) Bulk density/ Bulkage.

3.1.2.2 Coarse Aggregates

The coarse aggregate shall be crushed stone. Coarse aggregate obtained from crushed or broken stone shall be angular, hard, strong, dense, non-porous, durable, clean and free from soft, friable, thin plate, elongated or flaky pieces and any deleterious material.

River gravel or pit gravel shall be sound, hard, clean, non-porous, suitably graded in size with or without broken fragments and free from flat particles of shale, clay, silt, loam, and other impurities

Except where it can be shown to the satisfaction of the Engineer that a supply of properly graded aggregates of uniform quality can be maintained over the said period of the works, the grading of aggregates shall be controlled by obtaining the coarse aggregates in different sizes and blending them in correct proportions as and when required.

All coarse aggregates shall conform to IS: 383 and tests for conformity shall be carried out as per IS: 2386, Parts I to VIII.

The maximum size of coarse aggregates shall be such that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of formwork. Unless otherwise permitted by the Engineer the nominal maximum size shall not exceed 20 mm.

Water absorption shall be less than 3% by weight (ASTM C 117)

3.1.2.3 Chloride Content

The chloride content of aggregates shall be within the recommended limits stated in IS: 383 or BS 882 and the chloride content of the concrete mix shall be within the recommended limit of IS: 456 or BS 8110. Chloride levels shall be determined daily in accordance with the methods described in BS 812.

3.1.2.4 Alkali-Silica Reactivity

If aggregates contain any materials which are reactive with alkalis in any of the constituents of the concrete, or in water which will be in contact with the finished work, then the Contractor shall take samples of these materials every week. The Contractor shall ensure that the concrete mix complies with the requirements of this Specification regarding "Minimizing risk of alkali-silica reaction in concrete", vide clause 3.4. The

results of the Contractor's weekly monitoring tests shall be submitted in writing to the Engineer.

3.1.2.5 Sulphate Content

The total acid soluble sulphate content of the concrete mix, expressed as SO₃, shall not exceed the recommended limit in IS: 456 or BS 8110.

3.1.3 Water

Water used in the works shall be potable water and free from deleterious materials. Water used for mixing and curing concrete as well as for cooling and/or washing aggregate shall be fresh, clean and free from injurious amounts of oil, salts, acids, alkali, other chemicals and organic matter.

Water shall be from the source approved by the Engineer and shall be in accordance with clause 5.4 of IS: 456 However, chloride content in water shall not exceed 500 mg/liter.

Before starting any concreting work and wherever the source of water changes, the water shall be tested in accordance with IS: 3025 for its chemical and other impurities to ascertain its suitability for use in concrete for approval of the Engineer. No water shall be used until tested and found satisfactory. Cost of all such Tests shall be borne by the contractor.

3.2 Blending of Aggregates

In order to obtain optimum workability, individual aggregates of nominal size 20 mm, 10 mm, 4.75 mm and 2.36 mm will be blended in such a way that the grading curve for all in aggregates will be a smooth curve from size 0.15 mm to 20 mm falling within the established envelope grading curve. Contractor shall establish envelope grading curve for each grade of concrete for given maximum size of aggregates and get it approved by Engineer before finalizing the mix design.

3.3 Admixtures

3.3.1 Chemical admixtures are not to be used until permitted by the Engineer. In case their use is permitted, the type, quantity/dosage and method of use of any admixture proposed by the Contractor shall be submitted to the Engineer for approval. The minimum cement content specified shall not be reduced on account of the use of the Admixtures.

3.3.2 The contractor shall further provide the following information concerning each admixture to the Engineer.

- a. Normal dosage and detrimental effects if any of under dosage and over dosage.
- b. The chemical names of the main ingredients in the admixtures.
- c. The chloride content, if any, expressed as a percentage by weight of admixture.
- d. Whether or not the admixture leads to the entrainment of air when used in the manufacturer's recommended dosage.
- e. Where two or more admixtures are proposed to be used in any one mix, the manufacturer's written confirmation of their compatibility etc.

3.3.3 In reinforced concrete works, the chloride content of any admixture used shall not exceed 2 percent by weight of the admixture as determined in accordance with IS:6925 and the total chloride and sulphate contents in concrete mix shall not exceed 0.15 and 4.0 percent respectively by weight of cement.

- 3.3.4** The admixtures when used shall conform to IS:9103. The suitability of all admixtures shall be verified by trial mixes.
- 3.3.5** The addition of calcium chloride to concrete containing embedded metal will not be permitted under any circumstances.
- 3.3.6** Retarding admixtures when used shall be based on lignous-Phonates with due consideration to clause 5.2 and 5.3 of IS: 7861.
- 3.3.7** Fiber reinforcement will be Propex (Fiber mesh 300-e3 / Fiber mesh 150-e3) or equivalent make polypropylene fibers, shall be added to ready-mixed concrete wherever the material is to be used for parapet, box girder. Bar reinforcement is still considered primary reinforcement. Under normal condition, add to the ready-mix at the plant in the quantity recommended by the manufacturer subjected to the approval of engineer-in-charge. If job conditions warrant, fiber reinforcement may be added at the jobsite provided that fibers are evenly distributed mix.
- 3.3.8** Micro silica (Silica fume) when used as mineral admixture in to concrete shall be conforming to ASTM C 1240 latest standards to establish specified strengths, durability and to meet special design objectives.

3.4 Minimizing the Risk of Alkali-Silica Reaction (ASR) in Concrete

1. Precautions against ASR in Concrete

Concrete mixes for use in the Permanent Works shall comply with one of the Subsections 2, 3 or 4. The Contractor shall notify the Engineer of his proposals for complying with this requirement.

2. The cementitious material shall have a reactive alkali content not exceeding a maximum value of 0.6% by mass when defined and tested as specified.

To combat the ASR, Micro silica shall be used in minimum 5% cement and shall not exceed 10% by the wt of cement in order to bind free alkalis early in plastic concrete and to reduce the permeability of concrete to prevent the moisture and external alkalis penetration.

OR

3. The total mass of reactive alkali in the concrete mix shall not exceed 3.0 kg/m³ of concrete when defined, tested and calculated as specified.

OR

4. The aggregate shall be classed as non-reactive in accordance with the definition in Subsection 14.

5. Cementitious Material (Hydraulic and Latent Hydraulic Binders):

6. The term alkali refers to the alkali metals sodium and potassium expressed as their oxides. The reactive alkali content of Portland cements shall be defined as the percentage by mass of equivalent sodium oxide (Na₂O) calculated from: -

% equivalent Na₂O = % acid soluble Na₂O + 0.658 x (% acid soluble K₂O)

7. The method used in determining the acid soluble alkali content of the materials shall be in accordance with BS 4550: Part 2: Subsection 16.2.

8. The Contractor shall make available the certified average acid soluble alkali content of Portland cement on a weekly basis.

9. The Contractor shall give immediate notice of any change which may increase the certified average acid soluble alkali content above the level used in the mix design for the concrete. A revised mix design for any concrete which would be affected by the increased alkali content shall be submitted for consent with notification of the change.

10. Minimizing the Risk by Using Cementitious material containing less than 0.6% Reactive Alkali. The requirements of Subsection 2 will be met by Subsection 11 provided that the contribution of alkalis from other sources does not exceed 0.2 kg/m³ (see Subsections 14 and 21). Where alkalis exceed 0.2 kg/m³ the requirements of Subsections 12 to 15 shall apply.

11. The cementitious material shall be Portland cement complying with Indian Standard and shall have additionally a certified maximum acid soluble alkali content not exceeding 0.6%.

The Contractor shall provide on request weekly certificates which name the source of the cement and confirm compliance with the Specification.

12. Minimizing the Risk by Limiting the Reactive Alkali Content of the Concrete to 3.0 kg/m³. The requirements of Subsection 3 will be met provided that Subsections 13, 14 and 15 are satisfied.

13. The reactive alkali content of the concrete contributed by the Portland cement to the concrete shall be calculated from:

$$A = \frac{C \times a}{100}$$

Where,

A = reactive alkali content of the concrete to the nearest 0.1 (kg/m³)

C = target mean Portland cement content of the concrete (kg/m³)

a = certified average acid soluble alkali content of the Portland cement (%).

14. Where reactive alkalis in excess of 0.2kg/m³ are contributed to the concrete from sources other than the cementitious material the limit of 3.0 kg/m³ from the cementitious material shall be reduced by the total amount so contributed.

The reactive alkali contributed by sodium chloride contamination of aggregates shall be calculated from:

$$H = 0.76 \times \{(NF \times MF) + (NC \times MC)\} \text{ (kg/m}^3\text{)}$$

Where H = equivalent alkali contribution made to the concrete by the sodium chloride

NF = chloride ion content of the fine aggregate as a percentage by mass of dry aggregates and measured according to BS 812: Part 4

MF = fine aggregate content (kg/m³)

NC = chloride ion content of the coarse aggregate as a percentage by mass of dry aggregate and measured according to BS 812: Part 4: 1976 (now in draft as Part 117)

MC = coarse aggregate content (kg/m³).

The factor 0.76 is obtained from a consideration of the composition of sea water.

The chloride ion content of aggregate sources containing 0.01% of chloride ion by mass or more shall be determined weekly in accordance with BS 812 or another approved method. When the chloride ion level is less than 0.01% it shall be regarded as nil.

15. The Contractor shall provide certificates on request confirming compliance with the Specification and stating:

- (a) The target mean cementitious material content of the concrete.
- (b) The names of the works manufacturing the cement.
- (c) A weekly report of the cement alkali determinations in accordance with Subsection 6.
- (d) The certified average acid soluble alkali content of the Portland cement.

16. Minimising the Risk by Using Selected Aggregates

Fine and coarse aggregate material shall comply with the requirements of IS:383 (and/or AASHTO Standard Specifications M6 and M80 respectively) to be taken out to conform to 512(2).

17. Water

Water for use in the manufacture of concrete shall be obtained from a public utility undertaking supply or from a source approved by Engineer and shall be of potable quality, and comply with the requirement of IS:456 and or BS 3148.

18. Where a potable mains supply is not available the Contractor shall obtain confirmation of the quality and reliability of the proposed source from the appropriate water authority and shall thereafter seek consent from the Engineer to use the proposed source.

19. Water other than from a public utility undertaking supply shall be sampled at a frequency to be determined by the Engineer and tested in accordance with the relevant provisions of IS:3025 or BS 3148. The sodium oxide and potassium oxide content shall be declared and expressed as equivalent Na₂O and shall be taken into account when calculating the total reactive alkali content of the concrete mix.

20. Admixtures and Pigments

Admixtures and pigments shall comply with the requirements of IS 9103 and IS:6925 or BS 5075 and BS 1014. The manufacturer's declared equivalent acid soluble alkali content and the dosage rate of any admixture or pigment to be incorporated shall be included with details of all concrete mixes submitted for consent.

21. The alkali content of admixtures shall be taken into account when determining the total equivalent alkali content of the concrete mix.

22. Micro silica (silica fume) shall be used in 5% by the weight of cement and shall not exceed 15% by the weight of cement.

3.5 Batching Plants, Mixers and Vibrators

3.5.1 Unless otherwise specified in the schedule of items, for all structural concreting work the Contractor shall provide automatic weigh-batching plant of suitable capacity. The plant used shall conform to IS: 4925. The batching plants shall have printing facilities to printout records of each batch in the format approved by the Engineer.

3.5.2 The Contractor shall provide Concrete mixers (IS: 1791 – Batch type concrete mixers, IS:2438 - Roller Pan Mixer) and Vibrators (IS:2505 - Concrete Vibrators Immersion Type,

IS:2506 - Screed board concrete vibrators supplied by recognized manufacturers and approved by Engineer.

3.6 Grade of Concrete

The concrete is designated as follows:

Concrete M 25 / 20

The letter M refers to the mix

The number 25 represents the characteristic compressive strength of 15cm cubes at 28 days in MPa (Mega Pascal's: 1 MPa: 10 kg/cm² approximately). M25 concrete thus has a characteristic strength of 250 kg/cm². Other mix design will also be denoted in same way.

The number 20 represents the nominal size of the coarse aggregates in mm.

3.7 Mix Design

It is the complete responsibility of the Contractor to design the concrete mixes by approved standard methods as per IS 10262 and to produce the required concrete conforming to the specifications and the strength, workability requirements approved by the Engineer.

Mix Design once approved must not be altered without prior approval of Engineer. However, should the contractor anticipate any change in quality and/or change in source of future supply of materials than that used for preliminary mix design, he should inform the Engineer quite in advance and bring fresh samples sufficiently in advance, to carry out fresh trial mixes. Design mix will indicate by means of graphs and curves etc., the extent of variation in the grading of aggregates which can be allowed.

Notwithstanding to the stipulations in any code, limits of Cement content, Water/Cement ratio & mineral admixture shall be followed as per the Table 3.7.1.

Table 3.7.1 Limits of Water/ Cement ratio, Cement content & mineral admixtures in concrete mixes

S. No	Description of Structural items/ elements	Applicable code	Grade of Concrete	Max. W/C ration	Min. cement content (kg/m ³)	Type/ Grade of Cement	Use of mineral admixture
	PCC works	IRS CBC	M20	0.50	240	OPC 43 or OPC 53 grade conforming to IS:269	Not permitted.
	Pile	IS 2911 (Part 1 Sec 2)	RCC M35	Slump 150mm to 180mm	400	Slag Cement conforming to IS 455 or site blending OPC53+GGBS	In case slag cement not used, GGBS is permitted to be used for part replacement of OPC to max. 50% by weight.
	Pile cap/ footing	IRS CBC	RCC M35	0.45	340	OPC 53 grade conforming to IS 12269	Permitted to use micro silica/ silica fumes or GGBS as per IS 456 over and above minimum cement content as
	Pier and pier cap		RCC M50	0.45	340		
	Slab & beams		RCC M50	0.45	340		

S. No	Description of Structural items/elements	Applicable code	Grade of Concrete	Max. W/C ratio	Min. cement content (kg/m ³)	Type/ Grade of Cement	Use of mineral admixture
							per mix design requirement.
	Superstructure		PSC M50	0.40	400	OPC 53 grade conforming to IS 12269	Not permitted
	PCC works	IS 456 & IS 2911 Part 1 Sec 2	M20	0.50	240	OPC 43(IS8112) or OPC 53 grade conforming to IS:12269	Not permitted.
	Pile		RCC M35	Slump 150mm to 180mm	400	Slag Cement conforming to IS 455 or site blending OPC53+GGBS	In case slag cement not used, GGBS is permitted to be used for part replacement of OPC to max. 50% by weight for blending.
	Pile cap/ footing	IS 456	RCC M35	0.45	340		
	RCC Columns		M35	0.45	340	OPC 53 grade conforming to IS:12269	Permitted to use micro silica/ silica fumes or GGBS as per IS 456 over and above minimum cement content as per mix design requirement.
	Slabs & beams		M35	0.45	340		

Maximum cementitious content in a mix which includes cement and mineral admixtures shall not exceed 500 Kg/m³.

Limits of Water and Cement Contents

Maximum water/cement ratio

- For RCC members including piles - 0.40
- For PSC members - 0.40

3.8 Cement Content

Ordinary portland cement (OPC) of 53 grade conforming to IS: 269-2015 shall be used. For pre-stressed concrete, cement conforming to codal specifications for OPC 53 grade cement shall be used.

As regards trial mixes, acceptance criteria, acceptance specification, lot size, sampling and testing and sampling size for piling work, PSC girders (cast-in-situ and precast post tensioned) and general work, the requirement of the relevant codes, standards and directions of the Engineer shall be followed.

3.9 Additional Tests for Concrete

As frequently as the Engineer may require, additional tests shall be carried out of concrete in addition to mandatory test specified in MORTH Specifications-2013(fifth revision), CPWD specifications -2009 and relevant IS Code.

3.9.1 Permeability test for Concrete:

The concrete will be verified for permeability by the following procedure and shall confirm to IS:3085-1965 - 'Permeability of Cement Mortar & Concrete'. Section 1716.5 of MORTH Specifications and DIN 1048.

1. The Engineer shall select random batches of concrete for examination at his discretion and sampling will generally be done at the point of discharge from the mixer and at placing point.
2. From the batches thus selected two concrete cylinders shall be made in accordance DIN 1048.
3. At least two cylinders shall be made on each day's concreting until 60 cylinders have been made for each grade of concrete. The cylinders will be tested as per the procedure, given in Clause 5 next.
4. All cylinders shall be made, cured, stored, transported and tested in accordance with clause 1716.5 of MORTH Specifications. The tests shall be carried out in a laboratory having NABL certification.
5. Test Procedure

The permeability of concrete will be verified by the following procedure:

- (i) Prepare a cylindrical test specimen 150 mm dia and 160mm high.
 - (ii) After 28 days of curing, test specimen will be fitted in a machine such that the specimen can be placed in water under pressure up to 7 bars. The typical machine shall be similar to one shown in Appendix 1700/II of MORTH.
 - (iii) At first a pressure of one bar is applied for 48 hours, followed by 3 bars for 24 hours and 7 bars for next 24 hours.
 - (iv) After the passage of the above period, the specimen is taken out and split in the middle by compression applied on two round bars on opposite sides above and below.
 - (v) The water penetration in the broken core is measured with scale and the depth of penetration assessed in mm (max permissible limit 25 mm).
6. Acceptability Criteria

The concrete shall pass the permeability test if it is properly compacted and is not considered permeable when tested as per DIN, and the water penetration in the broken core is less than 25mm as tested above.

No extra payment shall be made for this test and cost of the same should be included in the quoted rate for concrete work.

3.10 Batching of Concrete Ingredients

Unless permitted by the Engineer, all concreting shall be produced in computerized automatic weigh batching plant having printing facilities to print out records of each batch and installed at site. Ready Mixed Concrete (RMC) manufactured in computerized automatic weigh batching plant (as per specifications described above) by the approved agencies using the constituent materials from approved sources and approved mix design may also be used with prior approval from Engineer. Nothing extra shall be paid for such RMC used in the work including transportation, placing in position etc. However, in such cases the RMC production & transportation will have to be directly supervised by the

qualified personnel of the contractor. (Contractor has to setup his own batching plant(s). RMC from market will be permitted only in exceptional circumstances and to be decided by the Engineer.)

3.11 Placing Temperatures

During extreme hot or cold weather, the concreting shall be done as per procedures set out in IS:7861, Parts I & II.

In hot weather with temperature exceeding 40 degree C, the stock piles of fine and coarse aggregates for concreting shall be kept shaded from direct rays of sun and the concrete aggregates sprinkled with water for a sufficient time before concreting in order to ensure that the temperature of these ingredients is as low as possible prior to batching. The mixer and batching equipment shall be also shaded and if necessary painted white in order to keep their temperatures as low as possible. The placing temperature of concrete shall be as low as possible in warm weather and care shall be taken to protect freshly placed concrete from overheating by sunlight in the first few hours of its laying. The time of day selected for concreting shall also be chosen so as to minimise placing temperatures. In case of concreting in exceptionally hot weather the Engineer may in his discretion specify the use of ice either flaked and used directly in the mix or blocks used for chilling the mixing water. In either case, the Contractor shall not be paid extra for cost of ice, additional labour involved in weighing and mixing etc. All salt and saw dust shall be removed from ice before use. Quality of water used for making ice shall confirm to IS: 456.

3.12 Transporting, Placing, Compacting and Curing

Transporting, placing, compacting and curing of concrete shall be in accordance with IS: 456.

3.12.1 Transporting

The mix after discharging from the mixer shall be transported by transit mixers, buckets, pumps etc. or as approved by the engineer without causing segregation and loss of cement slurry and without altering its desired properties with regard to water cement ratio, slump, air content, cohesion and homogeneity. It should be ensured that the concrete is moved to its final destination before it attains an initial set.

The transportation is to be done by agitating transit mixers, pumps or other approved methods.

Water, Admixtures and Slump:

The amount of water required for proper concrete consistency shall take into account the rate of mixing, length of haul, time of unloading, and ambient temperature conditions.

Additions of water to compensate for slump loss should not be resorted to nor should the design maximum water-cement ratio be exceeded. Additional dose of retarder be used to compensate the loss of slump at contractor's cost, when permitted by Engineer. Retempering water shall not be allowed to be added to mixed batches to obtain desired slump.

3.12.2 Placing:

(i) Placing General

Concrete shall be placed in the position and sequence indicated on the Drawings, or as directed. Placing shall not be commenced until the fixing and condition of reinforcement

and items to be embedded and the condition of the containing surfaces or formwork has been approved. 24 hours written notification shall be given of the intention to place concrete. The thickness of horizontal layers shall not exceed 300 mm. Each layer of concrete shall be compacted fully before the succeeding layer is placed and separate batches shall follow each other close enough to ensure that the succeeding layer shall be placed and fully compacted before the layer immediately below has taken initial set. (The temperature to be maintained during pouring of concrete shall be refer to IS 7861 part 1 & 2.)

Concrete shall be transported by means which prevent contamination (by dust, rain etc.) segregation or loss of ingredients, and shall be transported and placed without delay.

Concrete shall be placed directly in its final position without segregation or displacement of the reinforcement, embedded items and formwork. Concrete shall not be placed in water, except as specified. Concrete shall not be dropped through a height greater than 1.5 metres.

(ii) Extent of Pours

The limit of individual pours and the height of lifts shall be as approved.

For walls, the length of panel placed at one time shall not exceed 6m; adjacent panels shall not be placed within 2 days, but shall be placed as soon as practicable thereafter. Subsequent vertical lifts shall not be poured within 2 days.

For piers and pier heads, portal columns the concreting is to be carried out in single stage i.e. in first stage concreting will be from kicker to just below pier head bottom and second stage of concreting will be pier head including shear key and cross girder (in station zone stages as given in drawings for all heights by using tremie/ pumps at the rate not more than 1.5m / hr or as approved by the Engineer.

Floors, roofs and ground slabs shall be placed in a sequence of pours to the approval of the Designer and the consent of the Engineer's Representative.

If the use of slip-forms or paving trains is permitted, these limits may be revised. The sequence of pours shall be arranged to minimise thermal and shrinkage strains.

(iii) Placing Equipment

Concrete shall generally be placed without segregation by pumping or bottom-opening skips. If chutes are used their slopes shall not cause segregation and spouts or baffles shall be provided.

(iv) Time for Placing

Concrete and mortar must be placed and compacted within 30 minutes of water being added to the mix or otherwise included via damp aggregates, unless admixtures are in use. Partially-set concrete shall not be used in the Works.

(v) Continuity of Placing

Placing in each section of work shall be continuous between construction joints. The Contractor shall make provision for standby equipment. If the placing of concrete is delayed due to breakdown, then the Contractor shall erect vertical stop-ends and form a construction joint or remove the concrete already placed and restart after repair of the breakdown, as directed.

(vi) Placing in Inclement Weather

Placing shall not take place in the open during storms or heavy rains. If such conditions are likely to occur the Contractor shall provide protection for the materials, plant and formwork so that work may proceed. If strong winds are prevalent protection from driving rain and dust shall be provided.

(vii) Placing in High Temperature and Low Temperature

The temperature of concrete shall not exceed 32° nor below 5o°C or the temperature stated in the table of Mixes whichever is the lower at the time of placing concrete. Also the maximum concrete temperature after placing shall not exceed temperature 50oC or 30oC above the concrete temperature at the time of placing whichever is the lower.

"Concrete in hot countries" published by FIP congress at New Delhi 1986 shall be complied with. The procedures the Contractor wishes to employ shall be subject to the Engineer's consent.

The Contractor shall supply suitable maximum/minimum thermometers and record the shade and sun temperatures at locations where concrete is being placed. Recommendations for cold weather concrete can be had from IS: 7861 (Part 2).

(viii) Placing at Night

If consent has been given for placing at night or in dark interiors, adequate lighting shall be provided where mixing, transportation and placing are in progress.

(ix) Placing Under Water

Underwater concrete shall be placed with minimum disturbance of the water. Running water and wave wash shall be controlled. The specified concrete grade shall be used and the mix design shall provide for good flowing ability.

Tremie pipes, bottom-dump skips or other approved placing equipment shall be used. Segregation shall be avoided.

Placing shall be commenced in approved sections and continued to completion.

The tremie pipe shall be buried in the concrete for at least 1.5m and the pipe must not be emptied until the pour is complete. If a bottom-dump skip is used, the contents shall be covered by canvas or similar before lowering into the water. The doors shall be opened when the skip is resting on the bottom with no tension in the support cable, and the skip shall be lifted gradually so that the concrete flows out steadily.

(x) Preparation Before Placing

Before placing concrete for reinforced work on the ground, the formation shall be compacted as specified and a screed of blinding concrete shall be applied to form a surface for construction.

Before placing concrete on or against rock, masonry, brickwork or old concrete, loose material shall be removed and the surface washed down; water seepage shall be stopped or channelled away from the work.

For mass concrete placed against masonry or brickwork the following shall apply:-

- ☐ The mortar joints in the facework shall have fully hardened.
- ☐ The water-cement ratio of the concrete shall be increased to compensate for the absorption of moisture by the existing work.
- ☐ The surface shall be soaked prior to placing.
- ☐ The concrete shall be worked around ties and bond stones and into open joints.

3.12.3 Compaction

Internal (needle) and surface (screed board) vibrators of approved make shall be used for compaction of concrete.

Internal vibrators shall be used for compaction of concrete in foundations, columns, buttresses arch section, slabs etc, and if required surface vibrators shall also be used. Depending on the thickness of layer to be compacted, 25 mm, 40 mm, 60 mm and 75 mm dia. internal vibrators will be used. The concrete shall be compacted by use of appropriate diameter vibrator by holding the vibrator in position until:

- i. Air bubbles cease to come to surface.
- ii. Resumption of steady frequency of vibrator after the initial short period of drop in the frequency, when the vibrator is first inserted.
- iii. The tone of the vibrated concrete becomes uniform.
- iv. Flattened, glistening surface, with coarse aggregates particles blended into it appears on the surface.
- v. Use of curing compounds may be permitted with specific approval of Engineer
- vi. After the compaction is completed, the vibrator should be withdrawn slowly from the concrete so that concrete can flow in to the space previously occupied by the vibrator. To avoid segregation during vibration the vibrator shall not be dragged through the concrete nor used to spread the concrete. The vibrator shall be made to penetrate, into the layer of fresh concrete below if any for a depth of about 150 mm. The vibrator shall be made to operate at a regular pattern of spacing. The effective radii of action will overlap approximately half a radius to ensure complete compaction.
- vii. To secure even and dense surfaces free from aggregate pockets, vibration shall be supplemented by tamping or rodding by hand in the corners of forms and along the form surfaces while the concrete is plastic.
- viii. A sufficient number of standby vibrators shall be kept readily accessible to the place of deposition of concrete to assure adequate vibration in case of breakdown of those in use.
- ix. Form vibrators whenever used shall be clamped to the sides of formwork and shall not be fixed more than 450 mm above the base of the new formwork and concrete shall be filled not higher than 230mm above the vibrator. The formwork must be made specially strong and watertight where this type of vibrator is used.
- x. Care must be taken to guard against over vibration especially where the workability of the concrete mix is high since this will encourage segregation of the concrete.
- xi. Plain concrete in foundations shall be placed in direct contact with the bottom of the excavation, the concrete being deposited in such a manner as not to be mixed with the earth. Plain concrete also shall be vibrated to achieve full compaction.

- xii. Concrete placed below the ground shall be protected from falling earth during and after placing. Concrete placed on ground containing deleterious substances shall be kept free from contact with such ground and with water draining there from during placing and for a period of seven days or as otherwise instructed thereafter. Approved means shall be taken to protect immature concrete from damage by debris, excessive loading, abrasion, vibrations, deleterious ground water, mixing with earth or other materials, and other influences that may impair the strength and durability of the concrete.

3.12.4 Field Control

Sampling at both, truck discharge and point of final placement shall be employed to determine the quality of concrete.

3.12.5 Curing

Curing of concrete shall be complete and continuous using potable water free from chlorides and sulphates water that is free of harmful amounts of deleterious materials that may attach, stain or discolor the concrete as per IS 456. Minimum wet curing will be for seven days by ponding water followed by moist curing by spraying water which shall be maintained up to a total period of at-least 14 days from the date of casting.

Immediately after compaction and completion of any surface finishes the concrete shall be protected from the evaporation of moisture by means of polythene sheathing, wet hessian or other material kept soaked by spraying. As soon as the concrete has attained a degree of hardening sufficient to withstand surface damage moist curing shall be implemented and maintained for a period of at least 15 days after casting.

- i. Method of curing and their duration shall be such that the concrete will have satisfactory durability and strength and members will suffer a minimum distortion, be free from excessive efflorescence and will not cause undue cracking in the works by shrinkage.
- ii. Steam curing with approved methodology can be adopted if required, for precast components. No extra payment will be made for adopting steam curing. Before concrete products are subjected to any accelerated method of curing, the cement to be used shall be tested in accordance with accepted standards (relevant IS codes) especially for soundness, setting time and suitability for steam curing. In the case of elements manufactured by accelerated curing methods, concrete admixtures to reduce the water content may be allowed to be as permitted by applicable codes of practice subject to the approval of the Engineer. The normal aeration agents used to increase the workability of concrete shall not be allowed. The steam curing of concrete products shall take place under hoods, under chambers or in tunnels. Use of insulated tarpaulin may be permitted. The steam shall have a uniform quality throughout the length of the member. The precast elements shall be stacked with sufficient clearance between each other and the bounding enclosure, so as to allow proper circulation of steam. The surrounding walls, the top cover and the floor of steam curing chamber or tunnel or hood shall be so designed as not to allow more than 1 kcal/m²/h/ deg C. The inside face of the steam curing chamber, tunnel or hood shall have a damp-proof layer to maintain the humidity of steam. Moreover, proper slope shall be given to the floor and the roof to allow the condensed water to be easily drained away. At first, when steam is let into the curing chambers, the air inside shall be allowed to go out through openings provided in the hoods or side walls which shall be closed soon after moist steam is seen jetting out. Preferably, steam should be let in at the top of the chamber through perforated pipelines to allow uniform entry of steam

throughout the chamber. In no case shall steam impinge directly on concrete products. The fresh concrete in the moulds shall be allowed to get the initial set before allowing the concrete to come into contact with steam. The regular heating up of fresh concrete product from 20 °C to 35 °C shall start only after a waiting period ranging from 2 to 5 hours depending on the setting time of cement used. The second stage in steam curing process shall be to heat up the concrete elements, moulds and the surroundings in the chamber. The airspace around the member shall be heated up to a temperature of 75°C to 80°C at a gradual rate, not faster than 30° per hour. This process shall continue 1 1/2 to 2 1/2 hours depending upon the outside temperature. The third stage of steam curing shall be to maintain the uniform temperature and pressure for a duration depending upon thickness of the section. This may vary from 3 to 5 1/2 hours. The fourth stage of steam curing shall be the gradual cooling down of concrete products and surroundings in the chamber and normalization of the pressure to bring it at par with the outside air. The maximum cooling rate, which is dependent on the thickness of the member, shall not exceed 30° per hour. In all these cases, the difference between the temperature of the concrete product and the outside temperature shall not be more than 60°C for concrete up to M 30 and 75°C for concrete greater than M 45. In the case of light weight concrete, the difference in temperature shall not be more than 60°C for concrete less than M 25. For concrete greater than M 50, the temperature differences may go up to 75°C. After the steam curing is completed, the elements shall be further water cured for about 3 to 7 days

- iii. Curing Compound shall be used with prior approval of Engineer. Clear, water based, nontoxic, non-film forming, reactive silicate treatment with indefinite shelf life suitable as complete replacement to any water curing procedures such as water soak ponding, blankets and plastic sheets for all horizontal and vertical surfaces Manufacturer shall supply written proof of completed, successful projects for up to 30 years. After completion of curing process, there should not be an requirement of removal or special preparation for surface applied adhesives flooring, coatings, patching, concrete stains, etc. Curing compound should have been successfully tested by CRRI as a replacement for water curing an accredited by IRC also. Material test result should be in compliance with ASTM C 309 and ASTM 1315". Curing compound shall be applied only for the structures which are approved by Engineer. It shall be applied as per the provisions of clause 1713.3 of MORTH specifications. No extra payment will be made for the same.
- iv. Water curing with sprinkler arrangement to be adopted for precast elements at Casting yard.

3.13 Joints

I. Construction Joints

Construction joints shall be located and the sequence of placing arranged as approved, to minimise shrinkage and thermal strains in the concrete.

Concrete placing shall not be interrupted except where joints occur, and shall continue after normal hours if necessary to achieve this.

Joints shall be formed square to the work with keyways included.

Before placing is resumed at a joint the set surface shall be roughened to remove laitance and expose the aggregate; the aggregate shall not be damaged. If damaging materials have come into contact with the surface of the joint the concrete shall be cut back and the roughened surface cleaned by compressed air or water jets and brushed

and watered immediately before placing. If required the surface shall be coated with a layer of stiff cement-grout prior to placing the new concrete.

Chemical surface-retarders shall not be used.

Construction joints shall be sealed with an approved sealant at external and liquid-contact faces.

Construction joints in water-retaining structures shall incorporate an approved waterstop with approved methodology.

No separate payment shall be allowed to the Contractor for forming construction joints including materials used for the purpose.

II. Expansion and Movement Joints

Expansion, contraction and other movement joints shall be incorporated in the works as shown on the Drawings.

Where shown on the Drawings approved, expansion joint fillers shall be supplied and installed. Filler material shall be stored flat on a dry surface adequately protected from rain or moisture in such a way that the material does not deteriorate. Filler material which has been damaged or has started to deteriorate shall not be incorporated in the works.

Movement joints shall be sealed with an approved sealant applied in strict accordance with the manufacturer's instructions to the dimensions shown on the Drawings. The surface of the concrete to which the sealant is to adhere shall be straight and cleaned of all filler material, dirt, oil, grease and other matter. The sealant shall be applied by methods recommended by the manufacturer so that the sealant is brought flush to the surface of structure and a smooth surface is achieved. Excess material and spillage shall be properly cleaned off and removed.

Dowel bars shall be installed and cast in across the movement joint wherever shown on the Drawings. The bars shall be straight with clean cut ends of the diameters and lengths as shown on the Drawings or in the Schedules. Cutting and cleaning of the dowel bars shall comply with the requirements of this Specification.

The bars shall be firmly supported in the positions shown on the Drawings so that they remain accurately parallel and are not displaced during the casting of the concrete in the first part of the structure. After the concrete has hardened and the formwork removed, the projecting ends shall be cleaned of all concrete spillage and painted with two coats of an approved bituminous paint and caps shall be fitted to the free ends of the bars. Dowel bar end caps shall be of cardboard or other material, of correct diameter for the dowel bar and of sufficient length to allow the specified movement of the two adjacent concrete structures. They shall be manufactured expressly for this purpose by an approved manufacturer.

The Contractor shall take care to protect the projecting ends of dowel bars from bending or other damage prior to concreting the succeeding bay. The bituminous paint shall be applied as soon as practicable, but end caps shall not be fitted until immediately prior to the succeeding concreting operations.

III. Water-stops

The layout and installation of the water-stops shall be in accordance with the manufacturer's recommendation and shall be subject to the approval of Designer and consent of Engineer.

IV. Bolts, Inserts and Openings

All fixing blocks, brackets, built in bolts, holes, chases, etc., shall be accurately set out and formed and carefully sealed prior to the concrete being placed. No cutting away of concrete for any of these items shall be done without the permission of the Engineer.

Bolts and other inserts to be cast into the concrete shall be securely fixed to the formwork in such a way that they are not displaced during the concreting operations, and that there is no loss of materials from the wet concrete through holes in the formwork.

Unless shown otherwise on the Drawings or the Engineer has given consent reinforcement shall be locally moved so that the minimum specified cover is maintained at the locations of inserts, holes, chases, etc

Temporary plugs shall be removed and the threads of cast in bolts shall be proved to be free and shall be greased before handing over any part of the Works. Construction joints in all concrete work shall be made as directed by the Engineer. Where vertical joints are required, these shall be shuttered as directed and not allowed to take the natural slope of the concrete.

3.14 Cracks

If cracks, which in the opinion of the Engineer may be detrimental to the strength construction, develop in concrete construction, the Contractor at his own expense shall test the structure as specified in "Loading Tests" of these Specifications.

If under such test loads the cracks develop further, the Contractor shall dismantle the construction, carry away the debris, replace the construction and carry out all consequential work thereto.

If cracks develop in the concrete construction, which in the opinion of the Engineer, are not detrimental to the stability of the construction, the Contractor at his own expense shall grout ths cracks with neat cement grout or with other composition (Epoxy Grout) as directed by Engineer and also his own expense and risk shall make good to the satisfaction of the Engineer.

External Shrinkage crack width shall be restricted to 0.25 mm on all viaduct structures and 0.30 mm on Station structures. If it is more than the above and in the opinion of Engineer may be detrimental to concrete construction, the contractor should test and make good the structure at his own expense with prior approval.

3.15 Defective Concrete

Should any concrete be found honeycombed or in any way defective, such concrete shall be rectified as per approved methodology by the contractor at his expense. If Engineer feels that repaired structure will not be having same strength or shape or uniformity with other exposed surface as original desired structure / original structure, the same shall be rejected by Engineer and required to be dismantled and disposed off by contractor at his own cost, as instructed by Engineer. Decision of the Engineer shall be final binding in this regard.

3.16 Exposed Faces, Holes and Fixtures

On no account shall concrete surfaces be patched or covered up or damaged concrete rectified or replaced until the Engineer or his representative has inspected the works and issued written instructions for rectification. Failure to observe this procedure will render that portion of the works liable to rejection.

Holes for foundation or other bolts or for any other purposes shall be moulded and steel angles, holdfasts or other fixtures shall be embedded, according to the drawing or as instructed by the Engineer.

3.17 Finishes

Unless otherwise instructed, the face of exposed concrete placed against formwork shall be rubbed down immediately on removal of the formwork to remove irregularities. The face of concrete for which formwork is not provided other than slabs shall be smoothed with a float to give a finish equal to that of the rubbed down face, where formwork is provided. The top face of a slab which is not intended to be covered with other materials shall be leveled and floated to a smooth finish at the levels or falls shown on the drawings or as directed. The floating shall be done so as not to bring an excess of mortar to the surface of the concrete. The top face of a slab intended to be surfaced with other material shall be left with a spaded finish. Faces of concrete intended to be plastered shall be roughened by approved means to form of a key.

3.18 Concrete for Flooring on Grade

Concrete for flooring on grade shall be placed in alternate bays not exceeding more than 4 m x 4m or as specified in the drawings including forming the joints or adjacent bays. The stiff mix shall be thoroughly vibrated and finished to receive the floor finish.

3.19 Grouting of Base Plates & Bolt Holes

3.19.1 Mixing

Dry grout should be mixed in a mechanical mixer: the conventional 200/400-litre capacity concrete mixer can be used to mix four bags of dry grout; alternatively, paddle type mortar mixers can be used. The quantity of grout to be mixed at one time should not exceed that amount which can be placed in approximately 10 to 15 minutes.

3.19.2 Batching

Batching of grout by fraction of a bag is not allowed. The quantity of mixing water should be the minimum commensurate with workability, compaction, and filling of the grout in all corners and crevices. Mixing should be done for a minimum of three minutes to obtain a fluid grout of uniform consistency.

3.19.3 Cleaning and preparation of the surface

The base concrete should be clean and strong, and its surface should be properly hacked; all dust should be removed by suction or compressed air. The surface should be thoroughly wetted with water for several hours. Before the grout is poured, all free water should be removed and the flat surfaces coated with a thin cement slurry.

3.19.4 Restraint

Heavy back-up blocks of timber or concrete should be fixed on all sides of the base plate to prevent escape of the grout, when poured through the openings provided in the base plate. Adequate restraint must be ensured on all the sides for a period of 7 days to obtain effective expansion and shrinkage compensation.

3.19.5 Curing

The grout should not dry out where external restraint is provided in the form of form-work, the top opening and all stray openings should be covered with wet sack for at least 7 days.

3.19.6 Placing and Compaction

The grout should be placed quickly and continuously either through the holes in the base plates or from one side only to ensure complete filling without entrapment of air. Grout should be properly spread and compacted by rodding. Excessive vibration should be avoided.

Below the bed plates, the grout should be compacted using long pieces of doubled-over flexible steel strapping or chains. The forward and backward movement of the strap or chain will assist in the flow of the grout into place. Steps must be taken to keep the grout in full contact with the underside of the bedplate until the grout sets; maintaining a small head of fresh grout in the forms.

3.19.7 Shrinkage Compensated Grout

Shrinkage compensated grout or non-shrinkable grout of approved manufacturer should be used. The batching shall be as per the manufacturer's specifications, other procedures being as above.

3.20 Pre-Cast Concrete

The provision in this section shall be considered supplementary to general provisions for reinforced concrete works.

3.20.1 Manufacture off the Site

1. Casting of members shall not begin until consent to the shop drawings, required computation, prestressing system (if required) and method of manufacture has been given and is approved by Engineer.
2. When the drawings and method of manufacture have been approved, no changes shall be made without the approval of designer and consent of the Engineer
3. The Contractor shall inform the Engineer in advance of the date of commencement of manufacture and casting of each type of member Concrete reinforcement and workmanship shall be as per IS:456.
4. A copy of all cube test results to the work shall be sent to the Engineer as soon it becomes available.
5. Where the Engineer requires tests to be carried out, no members to which the tests relate shall be dispatched to the Site until the tests have been satisfactorily completed and accepted.

6. All members shall be indelibly marked to show the Member Mark as described in the Contract, the production line on which they were manufactured, the date on which the concrete was cast and, if they are of symmetrical section, the face that will be uppermost when the member is in its correct position in the works. The markings shall be so located that they are not exposed to view when the member is in its permanent position.

3.20.2 Forms

1. The design and engineering of the forms and false work as well as their construction shall be the responsibility of the Contractor. Design of the false work for all concrete shall be done under the direction of a registered engineer based in Bangalore. All exposed surfaces of each element of the structure shall be formed with similar material to produce similar concrete surface textures, colour, and appearance. Forms shall be inspected and approved by the Engineer prior to authorizing casting operations. Details shown on the Drawings shall be built into the forms. Worn, damaged, or otherwise unacceptable forms shall be repaired before casting of any member will be authorised.
2. The forms may be made either of steel or of plywood. If the Contractor selects to use plywood forms, it shall be a high-quality plywood, 19mm minimum thickness, marine grade and it shall not be reused and shall be removed from site subject to the consent of the Engineer.
3. Forms shall be structurally adequate to support the members within permissible tolerances. The form design shall incorporate the method and the necessary hardware to adjust and maintain grade and alignment. Details of the hardware and adjustment procedure shall be included in the required plans.
4. Forms shall be coated with form release agent prior to use. Form release agent shall be a commercial quality form oil or other equivalent coating which will permit the ready release of forms and will not discolour the concrete. Excess form release agent shall not be allowed to stand in puddles in the forms nor shall coating be allowed to come in contact with reinforcing steel or hardened concrete.
5. Anchor devices may be cast into the concrete for later use in supporting forms, provided the arrangement is approved by the designer and consented by Engineer. The use of driven or drilled types of anchorages for fastening forms or form supports to concrete will not be permitted.

3.20.3 Curing

The steam curing shall be at 100% relative humidity to prevent loss of moisture and to provide moisture for proper hydration of the cement. Application of the steam shall not be directly on the concrete. During application of the steam, the ambient air temperature shall increase at a rate not to exceed 22°C per hour until the maximum temperature Curing shall comply with the requirements of specification.

Steam curing process may be used as an optional alternative to water curing at no extra cost to the employer. The casting bed for any unit cured with steam shall be completely enclosed to prevent steam escaping and exclude outside atmosphere. 2 to 4 hours after placing concrete and after the concrete has undergone initial set, the first application of steam shall be made, unless retarders are used, in which case the waiting period before application of the steam shall be increased to from 4 to 6 hours. Water curing methods shall be used from the time concrete is placed until steam is first applied.

Where the steam has been raised the maximum temperature shall be held until the concrete has reached the desired strength. In discontinuing the steam application, the ambient air temperature shall not decrease at a rate to exceed 22°C per hour until a temperature has been reached 10°C above the temperature of the air to which the concrete shall be exposed. The maximum curing temperature shall be from 60°C to 67°C. If the Contractor elects to cure by any other special method, the method and its details shall be subject to the approval of the designer and consent by Engineer.

3.20.4 Storage

When members are stored, they shall be firmly supported only at the points specified by the Designer. The accumulation of trapped water and deleterious matter in the units shall be prevented. Care shall be taken to avoid rust staining and efflorescence.

3.20.5 Handling and Transport

1. Members shall be lifted or supported only at points specified by the Designer or otherwise agreed by the Engineer and shall be handled and placed without impact.
2. The method of lifting, the type of equipment and transport to be used, and the minimum age of the members to be handled shall be subject to the Designer's requirements.

3.20.6 Assembly and Erection

The method of assembly and erection described in the Contract shall be as practicable and be strictly adhered to on site. Immediately after a unit is in position, and before the lifting equipment is removed, temporary supports or connections between members, as necessary, shall be provided. The final structural connections shall be completed as soon as possible.

3.20.7 Forming Structural Connections

1. No structural connections shall be made until the Engineer's consent has been given.
2. Unless otherwise agreed by the Engineer, the composition and water/cement ratio of the in situ concrete or mortar used in any connection and the packing of joints shall be in accordance with the assembly instructions.
3. Levelling devices shall only be released or removed with the consent of Engineer.

3.20.8 Epoxy Grout for Structural Connections (if required)

1. Description

Epoxy shall be furnished as 2 components which shall be mixed together at the Site.

2. Sampling and Testing

All tests will be conducted in accordance with the latest test methods of the American Society for Testing and Materials, Federal Test Method Standard No. 141 or equivalent British Standard.

3. Packaging, Labelling and Storing

Each component shall be packaged in steel containers not larger than 20 litres in volume. When the components are to be mixed at a ratio of 2 parts A to one part B, by volume, the container containing component B shall be one half the volume of the container containing component A. The containers shall have lug type crimp lids with ring seals, shall be new, not less than 0.6 mm nominal thickness, and shall be of such character as to resist any action by the components. Each container shall be clearly labeled with the designation (Component A or B), type (Standard or Rapid) if applicable, manufacturer's name, date of manufacture, batch number (a batch shall consist of a single charge of all components in a mixing chamber), lot number, all directions for use specified elsewhere and the following warning:

"CAUTION"

"This material will cause severe dermatitis if it is allowed to come in contact with the skin or eyes. Use gloves and protective creams on the hands. Should this material contact the skin, wash thoroughly with soap and water.

Do not attempt to remove this material from the skin with solvents. If any gets in the eyes, flush for 10 minutes with water and secure immediate medical attention." Attention is directed to the characteristic of some epoxy components to crystallize or thicken excessively prior to use when stored at temperatures below 2°C. Any material which shows evidence of crystallization or a permanent increase in viscosity or settling of pigments which cannot be readily redispersed with a paddle shall not be used.

4. Directions for Use

At the time of mixing, components A and B shall be at a temperature between 16°C and 29°C, unless otherwise specified. Any heating of the adhesive components shall be done by application of indirect heat. Immediately prior to mixing, each component shall be thoroughly mixed with a paddle. Separate paddles shall be used to stir each component. Immediately prior to use, the 2 components shall be thoroughly mixed together in the specified ratios. When mixed, all adhesives shall have an uniformly gray colour without black or white streaks. No solvent shall be added to any epoxy. After mixing, all epoxies shall be placed in the work and any overlaying or inserted be cleaned and it shall have moisture content of not more than 0.50% when tested. The maximum size of the aggregate shall not exceed that of material which is to be bonded to the work by the epoxy. It shall also be placed before thickening of the epoxy has begun. Surfaces upon which epoxy is to be placed shall be free of rust, paint, grease, asphalt, moisture and loose and deleterious material. When epoxy is used as a binder to make epoxy concrete or grout, the 2 components of epoxy shall be thoroughly mixed together before the aggregate is added and, unless otherwise specified, the mix proportions shall consist of one part of binder to approximately 4 parts of aggregate, by volume. Aggregate for use in epoxy concrete and grout shall one-fourth of the thickness of the joint to be grouted. All surfaces against which epoxy concrete and grout are to be placed shall be primed with a coat of the epoxy used just prior to placing the grout. No more material shall be mixed than can be used within 20 minutes from the time mixing operations are started. Pot life of the epoxy mixture shall be 45 minutes.

5. Epoxy Grout Strength Requirements

The compressive strength of 38 mm cubes of epoxy grout tested in accordance with ASTM C39 after 10 hours of curing at 20°C shall be not less than the design strength of the precast number.

3.20.9 Temporary Supports and Connections

Temporary supports provided during erection should take into account all construction loads likely to be encountered during the completion of joints between any combination of precast and in-situ concrete structural elements. The supports should be arranged in a manner that will permit the proper finishing and curing of any in-situ concreting and grouting associated with the precast member being supported when the gaps of joints have to be filled with concrete or mortar. They should first be cleaned and faces of the joints should be wetted. The mixing, placing and compacting of cement and mortar should be done with special care. Mortar of a dry consistency should be in the proportion of 1:1½ (1 part of cement to 1½ parts of sand) and should be placed in stages and packed hard from both sides of the joint.

3.20.10 Tolerances

The following tolerances apply to finished precast products at the time of placement in the structure. The forms must be fabricated / constructed to give a casting well within these limits:

1. Overall dimensions of members should not vary by more than + 6 mm per 3 m length with a maximum variation of + 20 mm.
2. Cross-sectional dimensions should not vary by more than the following:
 - + 3 mm for sections less than 150 mm thick
 - + 4 mm for sections over 150 mm & less than 450 mm
 - + 6 mm for sections over 450 mm to 1000 mm
 - + 10 mm for sections over 1000 mm
3. Deviation from straight line in long sections should not be more than + 6 mm for sections up to 3 m, + 10 mm for 3 m to 6 m, + 12 mm for 6 m to 12 m.

- (i) For tolerances on precast components, standard documents shall be followed
- (ii) Structural steel inserts/bolts for connecting precast concrete elements (Parapet to Box Girder)
Connection of precast concrete parapet with segmental box girder:

Square rods with internal threading and base plate/stiffener, shall be firmly fixed in the mould to the true line, level and alignment as shown in drawings. The threaded hole/pipe shall be properly protected so as to prevent ingress of mortar etc (by providing dummy bolts, PVC cover, cotton waste etc). For connection of parapet with segmental box girder bolts of required length having threads at both ends shall be provided as shown in drawings. Grade of steel will be in accordance with the values specified in the drawing. Welding to bolts is not permitted. Grade of nuts will be same as grade of respective bolts. It is imperative to verify that that bolts can be threaded smoothly at all times. Dummy bolts shall be used in the stacking yard as a protection measure to keep the threads clean free of dust / rust. Threading, bolts materials, tests etc shall be as per IS: 1367 part 1 to 16, IS: 1821-1987, IS: 4206.

Levelling bolts as shown in tender drawings are for facilitating alignment of the precast parapet.

3.21 Ready Mix Concrete and Pumping:

Ready-mixed concrete may be manufactured in a central automatic weigh Batching plant and transported to the place of work in agitating transit mixers.

The maximum size of coarse aggregate shall be limited to one-third of the smallest inside diameter of the hose or pipe used for pumping. Provision shall be made for elimination of over-sized particles by screening or by careful selection of aggregates. To obtain proper gradation it may be necessary to combine and blend certain fractional sizes of aggregates. Uniformity of gradation throughout the entire job shall be maintained.

The quantity of coarse aggregate shall be such that the concrete can be pumped, compacted and finished without difficulty.

Fine aggregates:

The gradation of fine aggregate shall be such that 15 to 30 percent should pass the 0.30 mm screen and 5 to 10 percent should pass 0.15 mm screen so as to obtain pumpable concrete. Sands, which are deficient in either of these two sizes, should be blended with selected finer sands to produce these desired percentages. With this gradation, sands having a fineness modulus between 2.4 and 2.8 are generally satisfactory. However, for uniformity, the fineness modulus of the sand should not vary more than 0.2 from the average value used in proportioning.

Water, Admixtures and Slump:

The amount of water required for proper concrete consistency shall take into account the rate of mixing, length of haul, time of unloading, and ambient temperature conditions.

Additions of water to compensate for slump loss should not be resorted to nor should the design maximum water-cement ratio be exceeded. Additional dose of retarder be used to compensate the loss of slump at contractor's cost, when permitted by Engineer. Retempering water shall not be allowed to be added to mixed batches to obtain desired slump.

Transportation:

The method of transportation used should efficiently deliver the concrete to the point of placement without significantly altering its desired properties with regard to water-cement ratio, slump, and homogeneity.

The revolving-drum truck bodies of approved make shall be used for transporting the concrete. The numbers of revolutions at mixing speed, during transportation, and prior to discharge shall be specified and agreed upon. Reliable counters shall be used on revolving-drum truck units. Standard mixer uniformity tests, conforming to ASTM standards C 94-69 "Standard Specifications for Ready Mix Concrete", shall be carried out to determine whether mixing is being accomplished satisfactorily.

Pumping of concrete:

Only approved pumping equipment, in good working condition, shall be used for pumping of concrete. Concrete shall be pumped through a combination of rigid pipe and heavy-duty flexible hose of approved size and make. The couplings used to connect both rigid and flexible pipe sections shall be adequate in strength to withstand handling loads during erection of pipe system, misalignment, and poor support along the lines. They should be nominally rated for at least 3.5 MPa pressure and greater for rising runs over 30 m. Couplings should be designed to allow replacement of any section without moving other

pipe sections, and should provide full cross section with no construction or crevices to disrupt the smooth flow of concrete.

All necessary accessories such as curved sections of rigid pipe, swivel joints and rotary distributors, pin and gate valves to prevent backflow in the pipe line, switch valves to direct the flow into another pipe line, connection devices to fill forms from the bottom up, extra strong couplings for vertical runs, transitions for connecting different sizes of pipe, air vents for downhill pumping, clean-out equipment etc, shall be provided as and where required. Suitable power-controlled booms or specialized crane shall be used for supporting the pipe line.

Field control:

Sampling at both truck discharge and point of final placement shall be employed to determine if any changes in the slump and other significant mix characteristics occur. However, for determining strength of concrete, cubes shall be taken from the placement end of line.

Planning:

Proper planning of concrete supply, pump locations, line layout, placing sequence, and the entire pumping operation shall be made and got approved. The pump should be as near the placing area as practicable, and the entire surrounding area shall have adequate bearing strength to support concrete delivery pipes. Lines from pump to the placing area should be laid out with a minimum of bends. For large placing areas, alternate lines should be installed for rapid connection when required. Standby power and pumping equipment should be provided to replace initial equipment, should breakdown occur. The placing rate should be estimated so that concrete can be ordered at an appropriate delivery rate. As a final check, the pump should be started and operated without concrete to be certain that all moving parts are operating properly. A grout mortar should be pumped into the lines to provide lubrication for the concrete, but this mortar shall not be used in the placement. When the form is nearly full, and there is enough concrete in the line to complete the placement the pump shall be stopped and a go-devil inserted and shall be forced through the line by water under pressure to clean it out. The go-devil should be stopped at a safe distance from the end of the line so that the water in the line will not spill into the placement area. At the end of placing operation, the line shall be cleaned in the reverse direction.

3.22 Additional Specifications for Concrete M60 and above

- (a) Mineral admixture in the form of micro silica or condensed silica fume shall be permitted in the design mix. It shall comply with ASTM C 1240 "Specifications for Silica Fume for use in Hydraulic Cement Concrete and Mortar". It shall be obtained from proven and reliable manufacturer/supplier to the satisfaction of the Engineer.
- (b) Adequate and complete dispersal of the micro silica during the concrete mixing shall be ensured.
- (c) When micro silica is used in powder form the contractor shall take all precautions against potential health hazards during handling of the material.
- (d) Chilled water and/ or ice shall be used in the concrete mix depending on the ambient temperature, dimensions of the concrete element, rate of pouring and design mix constituents.

- (e) Special profuse curing arrangements shall be made for dissipation of the heat of hydration. The water curing shall be continued for a period of 21 days.
- (f) The concrete design mix and arrangement for mixing, transportation, and curing of concrete shall be subject to the approval of the Engineer.
- (g) In accordance with IRC SP 47

3.23 Testing Concrete Structures for Water Tightness & Acceptance Criteria Underground Structures, Pump Rooms and Sumps

In the case of structures whose external faces are submerged and are not accessible for inspection, such as underground structures, the structures shall be filled with water and after the expiry of seven days after the filling, the level of the surface of the water shall be recorded. The level of water shall be recorded again at subsequent intervals of 24 hours over a period of seven days. Backfilling shall be withheld till the tanks are tested. The total drop in surface level over a period for seven days shall be taken as an indication of the water tightness of the structure.

A structure shall be deemed to be water tight if the total drop in the surface level over a period of seven days does not exceed 40 mm.

Roofs

The roofs of liquid-retaining structures shall be water-tight and shall be tested on completion by flooding the roof with water to a minimum depth of 25 mm for 24 hrs. Where it is impracticable, because of roof falls or otherwise, to contain a 25 mm depth of water, the roof shall have water applied by a continuous hose or sprinkler system to provide a sheet flow of water over the entire area of the roof for not less than 6 hrs. In either case the roof shall be considered satisfactory if no leaks or damp patches show on the soffit. Should the structure not satisfy either of these tests, then after completion of the remedial work it should be retested in accordance with this clause. The roof insulation and covering should be completed as soon as possible after satisfactory testing. Contractor shall give warranty for leak tightness of joints for 10 years.

Measurement:

Unless otherwise specified the cost of formwork deemed to be included in concrete cost. The reinforcement shall be paid separately under relevant schedule of BOQ.

The volume of concrete measured shall include that occupied by:

- 1 Reinforcement and other metal sections.
- 2 Cast in components each less than 0.01 m³ in volume.
- 3 Rebates fillets or internal splays each less than 0.005 m² in cross sectional area.
- 4 Pockets and holes not exceeding 0.01 m³ in volume.
- 5 For M-10 concrete no payment shall be made for any shuttering used.
- 6 Rates for precast concrete shall include demoulding, handling, storing, transporting and erecting at site, including all clamping, bracing that may be required during erection including erection equipment.

3.24 Concrete Cube Tests:

The quality of hardened concrete will be verified by the following procedure:

1. The Engineer shall select random batches of concrete for examination without warning the Contractor and sampling will generally be done at the point of discharge from the mixer.
2. From the batches thus selected 6 concrete cubes shall be made in accordance with Indian Standards. However not more than 2 cubes may be made from any single batch. Of these 6 cubes thus made 3 cubes (each cube representing concrete of different batches) shall be tested at 7 days and the remaining 3 cubes shall be tested at 28 days.
3. All cubes shall be made, cured, stored, transported and tested in accordance with Indian Standards. The tests shall be carried out in a laboratory approved by the Engineer.
4. At least 6 cubes shall be made on each day's concreting until 60 cubes have been made for each grade of concrete. This is the initial period.
5. After the initial period, subject to the acceptance of the Engineer, the frequency at which the cubes shall be made may be reduced as follows:

(1 set = 6 cubes, each pair of cubes representing concrete from a different batch.) At least 1 set for each day's concreting consisting of:

- a) 1 set for every 10m³ or part thereof of concrete for critical structural elements like columns, parapet, segments, larger cantilever, plus.
- b) 1 set for every 40m³ or part thereof for all other elements.

If concrete is batched at more than one point simultaneously, the above frequency of making cubes shall be followed at each point of batching. 3 of the cubes of each set shall be tested at 6 days and the remaining 3 cubes shall be tested at 28 days from the day of casting the cubes.

3.25 Failure to meet specified Requirements:

1. If from the cube test results it appears that some portion of the Works has not attained the required strength, the Engineer may order that portion of the structure be subjected to further testing of any kind whatsoever as desired by the Engineer, including, if so desired by him, full load testing of the suspected as well as adjacent portions; of the structure as specified in the Conditions of Contract. Such testing shall be at the Contractor's cost. The Engineer may also reject the work and order its demolition and reconstruction at the Contractor's cost.
2. If the strength of concrete in any portion of the structure is lower than the required strength, but is considered nevertheless adequate by the Engineer so that demolition is not necessary, the Contractor shall be paid a lower rate for such lower strength concrete as determined by the Engineer.

SECTION- S.04

4. FORM WORK

4.1 General

These specifications shall be read in conjunction with the MORTH specifications-2013 (fifth revision) and CPWD specifications - 2009 with correction slips / amendments upto date, and other relevant specifications described in the section 1 of these specifications.

4.2 Materials

Formwork shall be of timber, plywood (including marine plywood), steel or any other suitable material capable of resisting damage to the contact faces under normal conditions of erecting forms, fixing steel and placing concrete. The selection of materials suitable for formwork shall be made by the Contractor based on the quality consistent with the specified finishes and safety. For designated areas prominently in public view like piers, piers caps, portals, viaduct (cast-in-situ or pre-cast), parapet etc., only steel shuttering shall be used. Steel material shall be in good condition. It should not be corroded. Condition of material shall be decided by engineer and If find not as per Indian standards or not as per requirement it shall be replaced. Number of uses for steel shuttering shall be between 50 and 100. Uses shall be decided by engineer as per the condition of steel shuttering. Special finishes like grooves, logos, floral designs, engraving in inset and outset shall be provided by fixing monolithic rubber forms fixed on entire surface of the formwork. The minimum shore hardness of rubber shall be A-55 to ensure strength, flexibility & elasticity. The contours, design and edges of rubber form should be smooth to ensure minimal deposition of grime or dust. The material shall be approved by the Engineer before erected at site. However, the entire responsibility of planning, designing, erection, dismantling, shifting and safety of false work lies with the contractor.

All formwork and formwork support (centering, props, scaffolds, ladders etc.) shall be in structural steel only and preferably of pipes conforming to IS: 806, IS:1161, IS:1239, IS:2750. Wooden ballies shall not be permitted as props/formwork supports. All props shall be properly braced using x & k bracings. Ladders to be used at site should have treads and shall be fabricated from structural steel. Wooden / bamboo / aluminum / pipe ladders shall not be permitted.

4.2.1 Timber

Timber used for formwork shall be easily workable with nails without splitting. It shall be stable and **not** liable to warp when exposed to sun and rain or wetted during concreting.

4.2.2 Plywood

Plywood used for formwork shall be minimum 12 mm thick. Shuttering quality plywood complying with IS:4990 and of make approved by the Engineer. Suitable stiffeners and walers shall be provided depending on the shuttering design.

4.2.3 Steel

Steel formwork shall be made of minimum 4 mm thick black sheets stiffened with angle iron frame made out of M.S. angles 40 mm x 6 mm supported at suitable spacing.

4.3 Design & Drawings

All temporary works such as formwork, false work, staging, launching girder, cantilever form traveler scheme etc. shall be designed by the Contractor. The permissible stresses in materials of formwork, false work, staging, launching girder & cantilever form traveler shall be same as for permanent structure. All calculations and drawings of the same including construction sequence shall be checked and verified by independent agency appointed by contractor. Only after the checking of the same, the calculations and drawings (along with soft copy in CD ROM) shall be submitted to Engineer for approval well in advance of work.

All temporary works shall be also inspected by the independent agency and independent report shall be submitted to Engineer. All temporary works shall be robust, safe and constructed such a way that the concrete can be properly placed and thoroughly compacted to obtain the required shape, position and level subject to specified tolerances. It is the responsibility of the Contractor to obtain the results required by the Engineer, whether or not some of the work is sub-contracted. Approval of the temporary works by the Engineer shall not diminish the Contractor's responsibility for the satisfactory performance of the same, nor for the safety and co-ordination of all operations.

For pier formwork, it shall be ensured that total deflection (taking account of combined deflection of plate, stiffeners, walers or any other supporting arrangement) shall not be more than 3mm. All the formwork, launching truss and cantilever form traveler and other selected temporary works shall be tested for the load including factor of safety for which the truss/formwork is designed before use in works.

The design of false work should be such as to facilitate easy and safe access to all parts for proper inspection.

Methodology for removal of form should be planned as a part of total form work design process. In case of pre-stressed concrete work, careful consideration shall be given to re-distribution of loads due to pre-stressing.

4.4 Formwork for Exposed Concrete Surfaces

The facing formwork, unless indicated otherwise in drawings, or specifically approved by the Engineer in writing, shall generally be made with materials not less than the thickness mentioned below for different elements of the structure:

- 4.4.1** Plain slab soffit, and sides of beams, girders, joists and ribs and side of walls, fins, parapets, pardis, sun-breakers, etc shall be made with:
- a. Steel plates not less than 4mm thick of specified sizes stiffened with a suitable structural framework and fabricated true to plane
 - b. Timber planks of 20mm actual thickness and of specified surface finish, width and reasonable length,
 - c. Plywood not less than 12mm thick (IS:4990 - Specification for Plywood for Concrete Shuttering Work) stiffened with a suitable timber frame work or 3mm thick plywood with a 20mm timber plank backing, of specified sizes stiffened with a suitable timber framework and bracing. At joints 6mm/10mm sponge to be provided.
- 4.4.2** Bottoms of beams, girders and ribs, sides of columns shall be made with
- a. Steel plates not less than 5mm thick of specified sizes stiffened with a suitable structural framework, and fabricated true to plane

- b. Timber planks of 35mm actual thickness and of specified surface finish, width and reasonable length,
- c. Plywood not less than 12mm thick (IS: 4990), of specified sizes stiffened with a suitable timber framework.

4.4.3 For Precast segments, piers, pier heads, portals etc. suitable steel form work is to be used unless otherwise specified by Engineer.

4.5 Formwork for Sloped Surfaces

4.5.1 Forms for sloped surfaces shall be built so that the formwork can be placed board-by-board immediately ahead of concrete placement so as to enable ready access for placement, vibration, inspection and finishing of the concrete.

4.5.2 The formwork shall be built in such a way so that the boards can be removed one by one from the bottom up as soon as the concrete has attained sufficient stiffness to prevent sagging. Surfaces of construction joints and finished surfaces with slopes steeper than 2 horizontals:1 vertical shall be formed as required herein.

4.6 Formwork for Curved Surfaces

4.6.1 The contractor shall interpolate intermediate sections as necessary and shall construct the forms so that the curvature will be continuous between sections. Where necessary to meet requirements for curvature, the form lumber shall be built up of laminated splices cut to make tight, smooth form surfaces.

4.6.2 After the forms have been constructed, all surface imperfections shall be corrected and all surface irregularities at matching faces of form material shall be dressed to the specified curvature.

4.7 Formwork for Waffle Slab :

4.7.1 Shuttering for Waffle Slab/ Coffered Slab shall be with Fibre Glass moulds of approved design. They can also be of Precast concrete unit as per design to form as part of structural concrete. The moulds shall be of uniform shape and dimension to give the desired shape of Coffered slab.

4.8 Erection of Formwork

The following shall apply to all formwork:

4.8.1 To avoid delay and unnecessary rejection, the Contractor shall obtain the approval of the Engineer for the design of forms and the type of material used before fabricating the forms. (Ref. ACI 347 Formwork for Concrete or equivalent I.S. Code).

4.8.2 All shuttering planks and plates shall be adequately backed to the satisfaction of the Engineer by a sufficient number and size of walers or framework to ensure rigidity during concreting. All shutters shall be adequately struttred, braced and propped to the satisfaction of the Engineer to prevent deflection under deadweight of concrete and superimposed live load of workmen, materials and plant, and to withstand pouring rate and vibration.

4.8.3 Vertical props shall be supported on wedges or other measures shall be taken so that the props can be gently lowered vertically during removal of the formwork. Props for an upper level shall be placed directly over those in the level immediately below, and the

lowest props shall bear on a sufficiently strong area. Care shall be taken that all formwork is set plumb and true to line and level or camber or batter where required and as specified by the Engineer.

- 4.8.4** Provision shall be made for adjustment of supporting struts where necessary. When reinforcement passes through the formwork care should be taken to ensure close fitting joints against the steel bars so as to avoid loss of fines during the compaction of concrete.
- 4.8.5** If the formwork is held together by bolts, these shall be so fixed that no iron will be exposed on surfaces against which concrete is to be laid and within the concrete cover to the steel reinforcement. In any case wires shall not be used with exposed concrete formwork. The Engineer may at his discretion allow the Contractor to use tie-bolts running through the concrete and the Contractor shall decide the location and size of such tie-bolts in consultation with the Engineer. The tie bolts shall be so designed that their removal on de-shuttering does not leave any embedment within the concrete cover to steel reinforcement. Holes left in the concrete by these tie-bolts shall be filled by the concrete repair material and the methodology as approved by the Engineer at no extra cost.
- 4.8.6** Provision shall be made in the shuttering for beams, columns, and walls for a port hole of convenient size so that all extraneous materials that may be collected could be removed just prior to concreting.
- 4.8.7** Formwork shall be so arranged as to permit removal of forms without jarring the concrete. Wedges, clamps and bolts shall be used wherever practicable instead of nails.
- 4.8.8** The formwork for beams and slabs shall be so erected that forms on the sides of the beams and the soffit of slabs can be removed without disturbing the beam bottoms or props under beams.
- 4.8.9** Surfaces of forms in contact with concrete shall be oiled with a mould oil of approved quality form releasing agent. If required by the Engineer the contractor shall execute different parts of the work with different mould oils to enable the Engineer to select the MoRT&H suitable. The use of mould oil which results in blemishes of the surface of the concrete including diesel, burnt oil and any other lubricating oil shall not be allowed. Mould oil shall be applied before reinforcement has been placed and care shall be taken that no oil comes in contact with the reinforcement while it is being placed in position. The formwork shall be kept thoroughly wet during concreting and the whole time that is left in place. Nothing extra shall be paid to contractor for oiling the moulds.
- 4.8.10** Immediately before concreting is commenced, the formwork and other related arrangements shall be carefully examined to ensure the following:
- Removal of all dirt, shavings, sawdust and other refuse by brushing, washing and compressed air / vacuum cleaning.
 - The tightness of joints between panels of sheathing and between these and any hardened core.
 - The correct location of tie bars, bracing and spacers, and especially connections of bracing.
 - Adequate cover blocks are in place
 - Straightness and plumbness of the form work
 - Side supports / restraints for the form work are enough and robust
 - Construction joint (wherever applicable) is properly prepared
 - That all wedges are secured and firm in position.
 - That provision is made for traffic on formwork not to bear directly on reinforcing steel.

- j. Pouring platform along with its approach from ground is robust and safe for workers movement.
- k. Arrangement for vibrators for compaction of concrete
- l. Sequence of concrete pouring is well defined and is agreed upon by the Engineer and is explained to concrete pouring team
- m. The Pouring area is well lit.
- n. Curing arrangements are well planned and agreed upon by the Engineer.
- o. The green concrete protection measures from sun & rain etc. are in place.

4.8.11 The Contractor shall obtain the Engineer's approval for dimensional accuracies of the work and for the general arrangement of propping and bracing. (IS:3696 - Safety Code of Scaffolds and Ladders, IS:4014 Steel Tubular Scaffolding I & II). All scaffolding and staging shall be either of steel tubes or built-up section of rolled steel with adequate bracing at several levels in each perpendicular direction connecting each prop. In addition to this diagonal bracing should be provided in elevation ideally at 45 degrees or between 30 and 60 degrees. The Contractor shall be entirely responsible for the adequacy of propping, and for keeping the wedges and other locking arrangements undisturbed through the de-centering period. (IS:8989 Safety code for erection of concrete framed structures).

4.8.12 Formwork shall be continuously watched during the process of concreting. If during concreting any weakness develops and formwork shows any distress the work shall be stopped and remedial action as directed by the engineer shall be taken.

4.8.13 Staging for portal girder and cross girder (in station zone) shall be in the form of portal frame. It shall be ensured that minimum two lanes of traffic with a restricted height of 4.5m can ply underneath it with adequate protection to portal legs from moving traffic.

4.8.14 For concourse floor over road, the contractor shall design and fabricate prefabricated type of staging and shuttering which can be erected in very short duration. Such erection will be only permitted in the night. In such case staging has to span the full width of the road in a portal shaped profile as shown in tender drawings. The portal frame shall have 4.5m (min) traffic clearance from the road for allowing safe movement of traffic below. In case no road runs beneath the concourse zone of station, the bidder may decide whether to use the above form of staging or any normal staging arrangement from the ground itself.

4.9 Concrete Finishes

This section deals with the surface of concrete on which forms had been fixed while concreting.

4.9.1 Formed Surface

Allowable deviation from plumb or level and from the alignment profile, grades and dimensions shown on the drawings is defined as "tolerance" and is to be distinguished from irregularities in finishes as described herein. Tolerances in concrete construction are specified elsewhere.

The classes of finish and requirements for finishing of concrete surface shall be as shown on the drawings or as hereinafter specified. In the event of finishing not being definitely specified herein or in the drawings, finishes to be adopted shall be as directed by the Engineer.

Completed concrete surface shall be tested, where necessary to determine whether surface irregularities are within the limits specified hereinafter.

Surface irregularities are classified as "Abrupt" or "Gradual". Offsets caused by displaced or misplaced form sheathing, or form sections or by loose knots or otherwise defective timber form will be considered as abrupt irregularities, and shall be tested by direct measurements. All other irregularities shall be considered as gradual irregularities and will be tested by use of template, consisting of a straight edge or the equivalent thereof for curved surfaces. The length of the template shall be 150 cm for testing of formed surfaces and 300 cm for testing of unformed surfaces.

The classes of finish for formed concrete surfaces are designated by one of the symbols F1, F2, F3 and F4. Unless otherwise specified or indicated on drawings, these classes of finish shall apply as follows:

Finish F1: This finish applies to surfaces where roughness is not objectionable, or surface that will otherwise be permanently concealed. Surface treatment shall be the repair of defective concrete, correction of surface depressions deeper than 25 mm and filling of tie rod holes. Form sheathing will not leak mortar when concrete is vibrated. Forms may be manufactured with a minimum of refinement.

Finish F2: This finish is required on surfaces permanently but not prominently exposed to public view for which other finishes are not specified except F1. Forms shall be manufactured in a workmanlike manner to the required offsets or bulges. Surface irregularities shall not exceed 5mm for abrupt and 8mm for gradual irregularities measured with a 1.5 m template.

Finish F3: This finish is required for coarse textured concrete surfaces intended to receive plaster, stucco or wainscoting. Surface irregularities shall not exceed 5mm for both abrupt and gradual irregularities.

Finish F4: This finish is designated for surfaces prominently exposed to public view where appearance is also of special importance. This shall include piers of bridges, viaducts, beams, parapets, railings and decorative features on the structure and on the bridges. To meet with requirements for F4 finish, forms shall be manufactured in a skillful, workmanlike manner, accurately to dimensions. There should be no visible offsets, bulges or misalignment of concrete. At construction joints, the forms shall be rightly set and securely anchored close to the joint. Abrupt and gradual irregularities shall not exceed 3mm. Irregularities exceeding this limit shall be reduced by grinding to a level of 1:20 ratio of height to length. Jute bag subbing or sand blasting shall not be used.

4.9.2 Unformed Surfaces

The classes of finish for unformed surfaces are designated by symbols U1, U2, U3 and U4. Unless otherwise specified or indicated on drawings, these classes of finish shall apply as follows:

Finish U1: This finish applies to unformed surfaces that will be concealed permanently or otherwise where a screeded surface finish meets the functional requirements. Finish U1 is also used as the stage of finishes for U2 and U3. Finishing operations shall consist of sufficient leveling and screening to produce an even uniform surface. Surface irregularities shall not exceed 10mm.

Finish U2: This is floated finish, and used on all outdoor, unformed surfaces. Finish U2 is also used as the second stage of finish for U3. Floating to be performed manually or mechanically on stiffened screed surface shall be minimum to produce textured surface. If finish U3 is to be applied, floating shall be continued till a small amount of mortar without

excess water is brought to the surfaces so as to permit effective trowelling. Surface irregularities shall be removed as directed by the Engineer.

Finish U3: This is a trowelled finish and shall be used for tops of parapets, etc prominently exposed to view. When the floated surface has hardened sufficiently, steel trowelling shall be started. Steel trowelling on hardened, floated surface shall be performed with firm pressure to produce a dense uniform surface free from blemishes and trowel marks and having slightly glossy appearance. Surface irregularities shall not exceed 5mm.

Finish U4: This is a steel-trowelled finish, similar to finish U3, except that light surface pitting **and** light trowel marks such as obtained from the use of machine trowelling will be acceptable, provided that surface irregularities do not exceed the limits specified for finish U3.

Unformed surfaces which are nominally level shall be sloped for drainage as shown on drawings or as directed by Engineer unless the use of other slopes or level surface is indicated on drawings. Narrow surface such as tops of parapets, walls and kerbs shall be sloped approximately 1cm per 30cm of width. Broader surface such as roadways, platform and decks, shall be sloped approximately half centimeter per 30cm of width. Finishes of floor and roof slabs shall be sloped, if required, by the Engineer.

4.10 Exposed Concrete Work

Exposed concrete surfaces shall be smooth and even, originally as stripped without any finishing or rendering. Where directed by the Engineer, the surface shall be rubbed with carborundum stone immediately on striking the forms. The Contractor shall exercise special care and supervision of formwork and concreting to ensure that the cast members are made true to their sizes, shapes and positions and to produce the surface patterns desired. No honeycombing shall be allowed. Honeycombed parts of the concrete including the other surface defects in the concrete shall be removed by the Contractor as per the methods, which do not affect the strength of adjoining Concrete and as approved by the Engineer.

Part of defective concrete thus removed shall be re-cast using fresh concrete of same grade or approved quality concrete repair material depending upon the size, location, thickness of the defective concrete and structural behavior of the member having defective concrete as instructed by the Engineer without extra cost, For the purpose the Contractor shall prepare a comprehensive work procedure and get it approved from the Engineer. Nothing extra shall be paid for repair of the concrete. Contractor shall ensure that no air bubbles are formed on the exposed surface. Concrete pouring sequence, vibration methodology etc shall be planned to avoid air bubbles. All materials, sizes and layouts of formwork including the locations for their joints shall have prior approval of the Engineer.

4.11 Age of Concrete at Removal of Formwork

In accordance with CPWD Specifications 1996 / 2009 or IS:456. The Engineer may vary the periods specified if he considers it necessary. Immediately after the forms are removed, they shall be cleaned with a jet of water and a soft brush.

4.12 Stripping of Formwork

The work of form work removal should be planned and a definite scheme of operation worked out. Formwork shall be removed carefully without jarring the concrete, and curing of the concrete shall be commenced immediately. Concrete surfaces to be exposed shall, where required by the Engineer, be rubbed down with carborundum stone or bush-hammer to obtain a smooth and even finish. Where the concrete requires plastering or other finish later the concrete surface shall be immediately hacked lightly all over using approved methods and as directed by the Engineer. No extra charge will be allowed to the Contractor for such work on concrete surfaces after removal of forms.

4.13 Reuse of Forms

The Contractor shall not be permitted reuse of timber facing formwork brought new on the works for more than 5 times for exposed concrete formwork and 8 times for ordinary formwork. 5 or 8 uses shall be permitted only if forms are properly cared for, stored and repaired after each use. The Engineer may at his absolute discretion order rejection of any forms he considers unfit for use for a particular item irrespective of no of times the shuttering has been used and order removal from the site of any forms he considers unfit for use in the Works. Used forms brought on the site will be allowed proportionately fewer uses depending upon its condition and as decided by the Engineer. Use of different quality boards or the use of old and new boards in the same formwork shall not be allowed. If any other type of special or proprietary form work is used, the number of times they can be used will be determined by the Engineer.

4.14 Formwork for Precast/ Prestressed Concrete

1. The provisions in this section shall be considered supplementary to the general provisions stated above and additional Technical Specifications for pre cast segments. Precast concrete members and panels shall be made in accurately constructed moulds, on a properly prepared casting bed. All aspects of the making, curing and erection of precast units shall be subject to the approval of the Engineer.

The contractor shall submit detailed drawings of formwork for the approval of the Engineer. Finishing with cement mortar shall not be allowed.

2. The formwork should be so designed that it does not restrain the shrinkage movements and possible shortening due to pre-stress of the concrete. The formwork shall be of sturdy construction with special considerations to shutter vibrators when used. All edges and joints of the formwork should be designed and sealed so that no cement grout can escape and there is no wedging or keying to the concrete. The effect of curing on the formwork should be given special consideration. Depending on care, curing, erection and maintenance of the formwork after stripping, the following number of uses can be made with different types of formworks.

Plywood with timber backed formwork - As per satisfaction of Engineer

Steel moulds - -do-

Number of uses of shuttering to be as per approval of the Engineer

In case concrete moulds can be satisfactorily provided by the contractor, the Engineer's approval shall be obtained before use on the works.

3. Stripping

As soon as the pre-cast units have attained sufficient strength, the formwork shall be stripped. The pre-cast unit shall be lifted uniformly out of the formwork without being subjected to tilting or restraint effects.

4.15 Special Architectural Finishes

Special approved architectural finishes like grooves, logos, engravings/projections in inset and out set as per the approved design shall be provided by fixing monolithic rubber forms or any other approved material fixed on the entire surface of the form work. The shore hardness of the rubber shall be $600 \pm 5A$ to ensure strength, flexibility and elasticity. The rubber shall be cold cured (preferably polyurethane based) and fixed to the formwork under controlled conditions in shade and air temperature.

The form liners should be shrinkage free, solvent free and should be impervious to abrasion by Concrete, resistant to concrete pressure and heat resistant upto 700 C dry heat. Formwork liner fixation should be factory made under close tolerances and stage inspections.

If proprietary system of formwork is used, detailed information as given below herein shall be furnished to Engineer for approval before use.

1). General

- i). The information which the manufacturer is required to supply shall be in such detail as to obviate unsafe erection and use of equipment due to the intention of the manufacturer not having been made clear or due to wrong assumptions on the part of the user.
- ii). the user shall refer unusual problems of erection/assembly not in keeping with intended use of equipment, to the manufacturer of the equipment.

2). The manufacturers of proprietary systems shall supply the following information;

- (a) Description of basic functions of equipment.
- (b) List of items of equipment available, giving range of sizes, spans and such like, with manufacturer's identification number or other references.
- (c) The basis on which safe working loads have been determined and whether the factor of safety given applies to collapse or yield.
- (d) Whether the supplier's data are based on calculations or tests. This shall be clearly stated as there may be wide variations between results obtained by either method.
- (e) Instructions for use and maintenance, including any points which require special attention during erection, especially where safety is concerned.
- (f) Detailed dimensional information, as follows:
 - i. Overall dimensions, depths and widths of members.
 - ii. Line drawings including perspectives and photographs showing normal uses.
 - iii. Self-weight.

- iv. Full dimensions of connections and any special positioning and supporting arrangements.
 - v. Sizes of members, including tube diameters and thicknesses of material.
 - vi. Any permanent camber built into the equipment.
 - vii. Sizes of holes and dimensions giving their positions.
 - viii. Manner of fixing including arrangements for sealing joints.
 - ix. Method of de-stripping, storing & shifting.
- (g) Data relating to strength of equipment as follows:
- i. Average failure loads as determined by tests.
 - ii. Recommended maximum working loads for various conditions of use.
 - iii. Working resistance moments derived from tests.
 - iv. Working shear capacities derived from tests.
 - v. Recommended factors of safety used in assessing recommended loads and deflections based on test results.
 - vi. Deflections under load together with recommended pre-camber and limiting deflections.
 - vii. If working loads depend on calculations, working stresses should be tested. If deflections depend on theoretical moments of inertia or equivalent moments of inertia rather than tests, this should be noted.
 - viii. Information on the design of sway bracing against wind and other horizontal loadings.
 - ix. Allowable loading relating maximum extension of bases and/or heads.
 - x. Any restrictions regarding usage of any component or full assembly with regard to spans, heights and loading conditions

4.16 Measurement

Unless otherwise specified, the cost of form work etc., is included under relevant Concrete items of BOQ.

4.17 Information to be supplied by manufacturers of proprietary systems of form work

1. General

The information which the manufacturer is required to supply shall be in such detail as to obviate unsafe erection and use of equipment due to the intention of the manufacturer not having been made clear or due to wrong assumptions on the part of the user.

The user shall refer unusual problems of erection/assembly not in keeping with intended use of equipment, to the manufacturer of the equipment.

2. Information Required

The manufacturers of proprietary systems shall supply the following information;

- a. Description of basic functions of equipment.
- b. List of items of equipment available, giving range of sizes, spans and such like, with manufacturer's identification number or other references.
- c. The basis on which safe working loads have been determined and whether the factor of safety given applies to collapse or yield.
- d. Whether the supplier's data are based on calculations or tests. This shall be clearly stated as there may be wide variations between results obtained by either method.
- e. Instructions for use and maintenance, including any points which require special attention during erection, especially where safety is concerned.
- f. Detailed dimensional information, as follows:
 - i. Overall dimensions, depths and widths of members.
 - ii. Line drawings including perspectives and photographs showing normal uses.

- iii. Self-weight.
 - iv. Full dimensions of connections and any special positioning and supporting arrangements.
 - v. Sizes of members, including tube diameters and thicknesses of material.
 - vi. Any permanent camber built into the equipment.
 - vii. Sizes of holes and dimensions giving their positions.
 - viii. Manner of fixing including arrangements for sealing joints
- g. Data relating to strength of equipment as follows:
- i. Average failure loads as determined by tests.
 - ii. Recommended maximum working loads for various conditions of use.
 - iii. Working resistance moments derived from tests.
 - iv. Working shear capacities derived from tests.
 - v. Recommended factors of safety used in assessing recommended loads and deflections based on test results.
 - vi. Deflections under load together with recommended pre-camber and limiting deflections.
 - vii. If working loads depend on calculations, working stresses should be tested. If deflections depend on theoretical moments of inertia or equivalent moments of inertia rather than tests, this should be noted.
 - viii. Information on the design of sway bracing against wind and other horizontal loadings.
 - ix. Allowable loading relating maximum extension of bases and/or heads.
 - x. Any restrictions regarding usage of any component or full assembly with regard to spans, heights and loading conditions.

SECTION- S.05

5. REINFORCEMENT

5.1 General

These specifications shall be read in conjunction with the MORTH specifications -2013 (fifth revision) and CPWD specifications -2009 with correction slips / amendments upto date, and other relevant specifications described in the section 1 of these specifications.

Any steel specified for reinforcement shall conform in every respect to the latest relevant Indian Standard Specifications and shall be of tested quality under the ISI Certification Scheme.

All reinforcement work shall be executed in conformity with the drawings supplied and instructions given by the Engineer and shall generally be carried out in accordance with the relevant Indian Standard Specifications IS: 2502- Bending and Fixing of Bars for Concrete Reinforcement.

Reinforcing steel shall be of HYSD (Grade Designation Fe:500) Conforming to IS:1786, only TMT bar shall be supplied and used as reinforcement steel for the permanent work.

The reinforcement steel shall be from primary producers and no re-rolled steel shall be supplied and used. The contractor will produce copy of original challan / voucher as a proof of having purchased the steel reinforcement from approved manufacturers or their authorised distributors.

The steel reinforcement shall be brought to the site in bulk supply of 10 tonnes or more as decided by the Engineer. All reinforcement shall be stored horizontally above ground level on platforms, skids or other approved supports, clear of any running or standing water. Proper drainage of platform shall be provided. Steel reinforcement shall be stored in such a way as to avoid distortion and prevent deterioration by corrosion. Bars of different diameters shall be stored separately. A record shall be kept of the batch numbers of reinforcement deliveries in such a form that the part of works in which particular reinforcement is used can be readily identified.

5.2 Couplers Specifications

Only cold-forged, parallel threaded mechanical coupler system are recommended. All mechanical couplers shall be of Type 2 (or Class H as specified in IS-16172) and should be simple to install and which can be confirmed by quick visual inspection to have been correctly installed and to have achieved the required full-strength connection.

The couplers shall be of standard parallel thread type. Ends of the reinforcement bars, which are to be joined, shall be enlarged by cold forging/upsetting, threaded in such a way that root thread diameter is not lesser than the parent bar to be joined. The coupler shall be of TYPE – II and qualified/Certified as per UK CARES, IS code 16172:2014, ACI 318, ASME, Section III, and Div.2, Caltrans.

Couplers installed shall be strictly in accordance with the manufacturer's recommendations.

All the couplers shall undergo quality checks on uniformity of threads, dimensional accuracy etc. Each coupler shall be clearly stamped indicating batch number and diameter. This number shall be traceable to the original cast. The relevant material mill certificate shall be submitted with supply of a particular lot. The certificate shall give salient material properties. The coupler manufacturer shall operate at least an ISO 9000 approved quality assurance programme or equivalent for the manufacture of couplers.

Threading of ends of the reinforcing bars:

This threading activity shall preferably be done at Site. The various stages involved in threading are as given below:

a. Cutting (Rebar End Preparation):

The ends of reinforcement bars shall be cut by mechanical means to get a perfect plain and surface perpendicular to the axis of the bar.

b. Cold forging & threading:

After cutting the ends of the bar shall be enlarged by cold forging such that the area of cross section after threading shall not be less than the area of cross section of the parent bar. The length of cold forging shall be adequate for proposed thread length as per manufacturer's design. Threading shall be done preferably on threading machine. The threads shall be square parallel type to suit the couplers. The thread length and depth shall be as per manufacturer's design. After threading is completed, the threaded length of the bars shall be protected by providing plastic end caps before taking the bars out of the shop.

c. Quality control in making of threads:

Double forging of bars is not permitted. In case of improper cold forging the forged of the bar shall be square cut and fresh cold forging shall be undertaken. The threading shall be checked with 'go' and 'no go' gauges for the correctness of the thread profile on the rebar.

d. Qualification tests

The coupler shall be qualified as per IS code 16172:2014, ACI 318, ASME - Section III, and Div.2, Caltrans and must have conducted & qualified for the following tests :

(a). Static tensile test

Mechanical connections shall be tested for all reinforcing rebar sizes. For each rebar size, a minimum of three connections (3 joints + 1 Parent bar) in each load direction shall be tested in accordance with ASTM A370 test method to meet code requirement. A tensile test on an unsliced specimen from the same bar used for the spliced specimens shall be performed to establish actual tensile strength. The tensile strength of an individual splice system shall not be less than the 125% of the specified minimum yield strength (f_y of rebar) of the spliced bar.

(b). Cyclic tension and compression test

Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for cyclic tension & compression test. Each specimen shall withstand cycles of stress variation of the specified minimum yield strength of the reinforcing bar. The test should be carried out as per the table mentioned below:

Loading Stages and Cycles per stage for cyclic load test Stage	Tension	Compression	Cycles
1	0.95 f_y	0.5 f_y	20cycles
2	2 ϵ_y	0.5 f_y	4cycles
3	5 ϵ_y	0.5 f_y	4cycles

Note:

f_y is specified yield strength of the reinforcing bar.

ϵ_y is the strength of reinforcing bar at actual yield stress.

(iii) Cyclic tensile test

Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for low cyclic tensile test. Each specimen shall withstand 100 cycles of stress variation from 5% to 90% of the specified minimum yield strength (f_y) of the reinforcing bar. One cycle is defined as an increase from the lower load to the higher load & return.

(iv) Low cycle fatigue test (for 10,000 cycles)

Fatigue test shall be conducted on splice sample from +173 Mpa to -173 Mpa for 10,000 cycles. A sine wave form @ 0.5 Hz shall be followed for bar dia 36 mm & above and 0.35 Hz shall be followed for bar dia less than 36 mm. Test shall be conducted confirming to IS 16172:2014 & Caltrans specifications. Past certificates for low cycle fatigue test shall be accepted, however these should not be more than 3 years old.

(v) High cycle fatigue test (for 2,000,000 cycles)

In high cycle fatigue test, the test specimen is subjected to an axial tensile load which varies cyclically according to the sinusoidal wave form of constant frequency in the elastic range, as accordance with IS-16172. Past certificates for high cycle fatigue test shall be accepted; however these should not be more than 10 years old.

(vi) Slip test

Slip Test Shall be performed on each diameter coupler specimen as per ASTM A 370 section 10. Test shall be conducted confirming to IS 16172:2014 & Caltrans specifications. Total slip shall not exceed the max value of 0.1 mm. Refer table below for more details:

Bar diameter	TOTAL Slip (μ m)
8 mm to 20 mm	250
25 mm to 28 mm	350
32 mm to 40 mm	450
45 mm	600
56 mm	

(vii) Proof loading test

Every cold-forged, threaded bar end shall undergo a proof load test prior to leaving system supplier's workshop. Every threaded bar must be subjected to proof load testing to a minimum test loading of 75% of the characteristic strength (theoretical f_y). The system supplier shall essentially install a proof load tester equipment within its threading workshop premises and ensure to test each and every threaded bar. A positive indication shall be marked on the rebar to indicate that this operation has been carried out.

INSTALLATION OF COUPLERS IN THE FIELD:

The installation of couplers in the field, for joining reinforcing bars shall be undertaken by trained manpower and as per manufacturer's instructions. Threads of both the couplers and

the bars shall be thoroughly cleaned just before installation. Where couplers are cast-in the concrete, but connection is not to be completed immediately, the couplers shall be internally greased and plastic capped to a protection detail acceptable to the engineer. This cap shall be removed only when next bar is to be attached, then the same to be cleaned before joining the next bar.

The contractor shall arrange for a suitably qualified manufacturer's representative experienced in mechanically connecting reinforcement to be present at site before the start of work for initial training of personnel, and also to demonstrate the equipment and techniques as necessary. The threading workshop is to be fully supervised by the manufacturer's representative.

The contractor shall submit to the Engineer, for his acceptance a method statement for mechanically connecting the reinforcement and for the installation and verification in the field. This shall take into account any special requirements for horizontal, vertical and inclined couplers and shall include a rectification procedure, if the connection is incorrectly made. It shall also cover the correct methodology for handling of tools and equipment for mechanical connection on site. The following information shall also be included:

- a. Requirements for cleanliness
- b. Equipment for threading bars
- c. Method of making the connections on both rebars
- d. Method of verification of final rebars alignment and coupler integrity

Each coupler shall be visually examined prior to use to ensure the absence of rust and of any foreign material on the inside surface. All completed couplers shall be inspected and verified in accordance with the approved QAP. The Contractor shall ensure the acceptance of the Engineer for a procedure for documenting the inspection of the couplers. The contractor shall retain inspection records and shall submit copies to the engineer within 7 days. The Couplers that do not meet the acceptance shall be completely removed and the bars re-connected as required.

Reinforcement Coating

In order to offer adequate resistance against corrosion, reinforcement bars shall be provided with a coating of "Cement Polymer Composite Coating" OR "Fusion Bonded Epoxy Coating" as per IRS CBC clause 7.1.5 applicable for important and major bridges in aggressive environment (severe, very severe and extreme), which is the case for Bangalore environment.

5.3 Inspection & Testing

Every bar shall be inspected before assembling on the works and any defective pitted, brittle, excessively rusted or burnt bars shall be removed. Cracked ends of bars shall be cut out.

No work shall be commenced without the Engineer's approval of the bar bending schedule.

Manufacturer's test Certificate shall be supplied for each lot of supply.

Specimens sufficient for three Tensile Tests for each different size of bar for each consignment delivered, or for 10 tonnes of supply of that size, whichever is less shall be sampled and tested by the Contractor. Batches shall be rejected if the average results of each batch are not in accordance with the specifications.

5.4 Bar Bending and Bar Bending Schedule

All bars will be carefully and accurately bent by approved means in accordance with IS: 2502, and relevant drawings. It shall be ensured that depth of crank is correct as per the bar cutting and bending schedule. Bent bars are not straightened for use in any manner that will injure the material. No laps should be allowed for pre-cast segments and Piers, Pier caps. However, mechanical couplers are to be used without extra cost.

Prior to starting bar bending work, the Contractor shall prepare bar bending schedule from the structural drawings supplied to him and get the same approved by Engineer. Any discrepancies and inaccuracies found by the Contractor in the drawings shall be immediately reported to the Engineer whose interpretation and decision there to, shall be final.

5.5 Splicing (Laps, couplers, welds, etc)

Couplers:

These specifications cover threaded couplers to be used for joining reinforcement bars, in lieu of laps/welding/mechanical splicing.

SPECIFICATIONS

GENERAL

The couplers shall be of standard parallel square thread type. Ends of the reinforcement bars, which are to be joined, shall be enlarged by cold forging, threaded in such a way that thread diameter is not lesser than the parent bar to be joined. The material of the coupler shall be of same quality or of superior quality than the quality of material of the parent bars (i.e. reinforcement bars to be joined). The joint shall have guaranteed bar break i.e. when the joint is tested in universal tensile testing machine, the bar shall fail away from the coupler i.e. not within the coupler as well as within 2 times the diameter of bar from the ends of the coupler, which can be considered as affected zone. The Guaranteed Bar break condition is not mandatory, if the failure load of coupled specimen is higher than 1.15 times of its minimum specified yield stress. The coupler shall be qualified as per ASME, Section III, and Div.2. Additionally, it shall meet all the requirements of "Class II" type coupler as specified in IS 16172. The safety margin in coupler design shall be such that guaranteed bar break is ensured even if 15% of the total thread's length are out of coupler during installation.

The hand tightening of coupler shall be sufficient in the field and no mechanical means shall be essential for tightening. During testing, the coupler should only be hand tightened.

The process of manufacturing of the coupler, cold forging and threading including testing shall be carried out as per ASME approved quality assurance programme. The manufacturer of coupler shall hold a valid Quality System Certificate (QSC) from ASME. Installation of the coupler and supervision shall be done by the qualified personnel.

MANUFACTURING OF COUPLERS

All the couplers shall undergo quality checks on uniformity of threads, dimensional accuracy etc. Each coupler shall be clearly stamped indicating batch number, heat number and diameter. This number shall be traceable to the original cast. The relevant material mill certificate shall be submitted with supply of a particular lot. The certificate shall give salient material properties.

THREADING OF ENDS OF THE REINFORCING BARS

This threading activity shall preferably be done at site. The various stages involved in threading are as given below

CUTTING

The ends of reinforcement bars shall be cut by mechanical means to get a perfect plain end surface, perpendicular to the axis of the bar.

COLD FORGING & THREADING

After cutting, the ends of the bar shall be enlarged by cold forging such that the area of cross section after threading shall not be less than the area of cross section of the parent bar. The length of cold forging shall be adequate for proposed on lathe machine. The threads shall be square parallel type, to suit the couplers. The thread length and depth shall be as per manufacturer's design. After threading is completed, the threaded length of the bars shall be protected by providing plastic caps, before taking the bars out of the shop.

QUALITY CONTROL IN MAKING OF THREADS

The work in shop shall be fully supervised by the Manufacturer representative. Double forging of bars is not permitted. In case of improper cold forging, the forged end of the bar shall be square cut and fresh cold forging shall be undertaken. The threading shall be checked with 'go' and 'no go' gauges.

For threaded coupler systems, every prepared bar end shall undergo a load test prior to actual use. The minimum test loading shall be equivalent to 80% of specified yield strength of bar. For this purpose contractor shall deploy the machine having facility of integrated load testing. The 'Integrated' Load test the testing operation is performed automatically by the same machine used to prepare the bar ends. A positive indication shall be punched on the rebar to indicate that this operation has been carried out and bar end has qualified for specified strength.

INSTALLATION OF COUPLERS IN THE FIELD

The installation of couplers in the field, for joining reinforcing bars, shall be undertaken by trained manpower and as per manufacturer's instructions. Threads of both the couplers and the bars shall be thoroughly cleaned with acetone or any other solvent, just before installation.

Where couplers are cast-in the concrete, but connection is not to be completed immediately, the couplers shall be internally greased and plastic capped to a protection detail acceptable to the engineer. This cap shall be removed only when next bar is to be attached & then cleaned before joining the next bar.

The contractor shall arrange for a suitably qualified manufacturer's representative, experienced in mechanically connecting reinforcement, to be present at site before the start of work for initial training of personnel, and also to demonstrate the equipment and techniques as necessary.

The contractor shall submit to the Engineer, for his acceptance, a method statement for mechanically connecting the reinforcement and for the installation and verification in the field. This shall take into account any special requirements for horizontal, vertical and inclined couplers and shall include a rectification procedure, if the connection is incorrectly

made. It shall also cover the correct methodology for handling of tools and equipment for mechanical connection on site. The following information shall also be included:

- (a) requirements for cleanliness
- (b) equipment for threading bars
- (c) method of locking the connections on both rebars
- (d) method of verification of final rebar alignment and coupler integrity.

Each coupler shall be visually examined prior to use to ensure the absence of rust and of any foreign material on the inside surface. All completed couplers shall be inspected and verified in accordance with the approved QAP. The Contractor shall ensure the acceptance of the Engineer for a procedure for documenting the inspection of the couplers. The contractor shall retain inspection records and shall submit copies to the engineer within 7 days. The Couplers that do not meet the acceptance standards shall be completely removed and the bars re-connected, as required.

QUALIFICATION TESTS

The splices shall be qualified as per ASME Section III Div-2, IS 16172 and by conducting following tests:

STATIC TENSILE TEST

Mechanical connections shall be tested in all reinforcing rebar sizes. All rebar transition connectors shall also be tested. For each rebar size, a minimum of six connections in each load direction shall be tested in accordance with ASTM A370. A tensile test on an unspliced specimen from the same bar used for the spliced specimens shall be performed to establish actual tensile strength.

The average tensile strength of the splices shall not be less than the followings:

- a) 90% of the actual tensile strength of the reinforcing bar being tested.
- b) 100% of the specified minimum tensile strength

The tensile strength of an individual splice system shall not be less than the 115% of the specified minimum yield strength of the spliced bar.

CYCLIC TENSILE AND COMPRESSIVE TEST

Cyclic tensile and compressive test: Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for low cyclic tensile test. Each specimen shall withstand 100 cycles of stress variation from 5% to 90% of the specified minimum yield strength of the reinforcing bar. One cycle is defined as an increase from the lower load to the higher load & return. The test shall be performed as per Annexure D of IS 16172.

PERCENTAGE ELONGATION

The minimum uniform elongation (Elongation at maximum force) in the reinforcement bar outside the length of mechanical splice as measured as per Annexure B of IS 16172 shall be 3 % before failure of test piece.

SLIP TEST

The total slip value when measured in accordance to test procedure described in Annexure C of IS 16172 shall not exceed 0.10 mm.

TEST FOR AVOIDANCE OF STAGERRING

The strain measured over the full length of the splice at 90% of the specified minimum yield strength of the bar shall not exceed that of a bar that is not mechanically-spliced by more than 50%. The test shall be performed for all diameter of couplers.

LOW CYCLE FATIGUE TEST

The mechanical splice shall withstand 10000 cycles of alternating tension & compression load, when tested as per Annexure E of IS 16172.

HIGH CYCLE FATIGUE TEST

The mechanical splice when tested accordance to Annexure E of IS 16172 shall withstand 2 million cycles (2000000 Nos)of varying axial tensile load with a stress range of 60 MPa with upper stress in the test equal to 0.6fy.

PRODUCTION TESTS & ACCEPTANCE CRITERIA FOR A LOT

Static Tensile tests, as per ASTM A370, shall be conducted on each bar size & grade for each lot as follows. The criteria mentioned below are in variance with the above referred codes.

SI No	No of Coupler in the Lot	No of Sample to be Tested	Acceptable Defective Couplers
1	Upto 500	14	NIL
2	501 - 1200	20	NIL
3	1201-3200	32	1
4	3201-10000	50	2
5	10001 and above	50+ 2 for each 1000 Nos beyond 10000	Not more than 4% of the samples tested

The lot is defined as the group of couplers which are of same size, type, class, material traceable to same cast and manufactured under similar conditions of production. All the tests shall ensure guaranteed bar break at a load not lower than the specified tensile strength of the bar. The quoted rate shall be inclusive of carrying out above tests and no separate payment shall be made for these tests.

The Contractor shall submit to the engineer for acceptance a report on these Proving Tests, within seven working days of the tests. The report shall provide full details including:

- (a) Results of all tests
- (b) Details of dimensions, geometry. (c) Details of test procedures
- (d) Description of test rig/load cell
- (e) Description of load monitoring, strain measurements
- (f) Calibration certificates.

From each test on the coupler and control bar specimens, the following information shall be provided:

- a) Stress-Strain (or Load Displacement) curves
- b) Yield Load & Yield Strength
- c) Elongation of the mechanical connection
- d) Ultimate load & Ultimate Tensile Strength
- e) Mode of failure
- f) Gauge length used for strain measurement and statement of how gauge length was determined.

Lapping will not be permitted anywhere other than piles for bar dia of 20 mm and above.

5.6 Spacing, Supporting and Cleaning

All reinforcement shall be placed and maintained in the positions shown on the drawings.

The Contractor shall provide approved types of supports for maintaining the bars in position and ensuring required spacing and correct cover of concrete to the reinforcement as specified on the drawings. Cover blocks of required shape, size and strength M.S. Chairs and spacer bars shall be used to ensure accurate positioning of reinforcement. Cover blocks shall be cast well in advance and shall consist of approved proprietary pre-packaged free flowing mortars having the strength same as that of concrete for the member for which they are to be used. They shall be circular in shape for side cover and square for bottom cover. Cover blocks shall be cast and compacted using plate vibrator or any other approved method and shall be cured so as to achieve the desired strength. The cost of cover blocks and chairs/spacers shall be deemed to have been included in the rates.

Bars must be cleaned, before concreting commences, of all scale, rust or partially set concrete which may have been deposited there during placing of previous lift of concrete.

Cleaning of HYSD Bars.

Only TMT bars complying to IS:1786 shall be provided.

18 gauge 2 ply G.I. wire shall be used for binding reinforcement and as well as for typing cover blocks.

5.7 Welding

1. Wherever specified all lap and butt welding of bars shall be carried in accordance with IS: 2571. Only qualified welders duly tested and certified by the contractor shall be permitted to carry out such welding.
2. For cold twisted reinforcement welding operations must be controlled to prevent supply of large amounts of heat larger than that can be dissipated. The extreme non twisted end portion shall be cut off before welding. Electrodes with rutile coating should be used.
3. Bars shall be free from rust at the joints to be welded.
4. Slag produced in welding after each run should be chipped and removed by brush.
5. Electrode should not be lighted by touching the hot bar.

6. The welding procedure shall be approved by the Engineer and tests shall be conducted to prove the soundness of the welded connection.
7. E7018 electrode shall be used for Fe415 grade and E8018 electrode shall be used for Fe500 above as per AWS (American Welding Society) standards.

5.8 Measurement

Payment of reinforcement steel shall be made for the length of the reinforcement bars of different diameter as per bar bending schedule (to be prepared by the contractor on the basis of approved drawing).

S. No.	Bar Dia (mm)	Standard sectional weight in Kg./ m
1	6	0.222
2	8	0.395
3	10	0.617
4	12	0.888
5	16	1.578
6	18	2.000
7	20	2.466
8	22	2.980
9	25	3.854
10	28	4.830
11	32	6.313
12	36	7.990
13	40	9.864
14	45	12.490

The cost quoted should cover all welding, providing mechanical couplers, all types of laps, stiffeners, hooks, spacer bars, U-bars, standard laps, chair, bend deduction as per IS code, as required and nothing extra is payable on this account and also in case if it is recorded in bar bending schedule, payment will not be made for these bars. Payments shall not be made for butt welding and reinforcement bars used for lifting, hooks, handling, etc., as cost towards these is deemed to be included in the accepted rate of the item.

SECTION- S.06

6. PRESTRESSED CONCRETE

Structural concrete containing prestressed steel reinforcement to introduce pre-compression is termed as prestressed concrete.

6.1 General

The prestressed concrete work shall generally conform to IS: 1343 "Code of Practice for Prestressed Concrete" and Section 1800 of MORTH Specifications. The Concrete, Formwork and Non-tensioned reinforcement shall conform to relevant clauses in Section 3, 4 and 5 of this Specifications. The work shall be carried out in accordance with the drawing and these specifications or as approved by the Engineer.

Concrete and un-tensioned steel for the construction of prestressed concrete members shall conform to the requirements of sections respectively in so far as the requirements of these Sections apply and are not specifically modified by requirements set forth herein.

Contractor shall ensure that different components of prestressing such as jacks, bearing plates, wedges, anchorages, strands and HDPE ducts are compatible to one another and the same shall be exchanged in between all the suppliers to ensure the same.

6.2 Scope of Work:

The general scope of work will include:

- i. Providing and placing cement concrete with all ingredients and admixtures if and as required.
- ii. All arrangements needed to keep the reinforcement bars, pre-tensioned strands and sheathing in position with due spacing & cover blocks.
- iii. Providing steel shuttering, staging, scaffolding, erection & eventual removal.
- iv. Providing and placing in position and fixing permanent specialized bearings with the super structure, with their anchor bolts as per detailed specifications/instructions as stipulated, supplemented by manufacturer's specifications and directions of Engineer including grouting of holes etc. if any, with suitable grouts as approved by the Engineer.
- v. Installation of expansion joints in stages over the viaduct deck as per approved drawings and as per manufacturer's specifications/directions of Engineer.
- vi. Contractor to furnish facility for fixing/embedding all necessary electrical or other fixtures by the designated contractors at site.
- vii. Providing and mixing cement concrete with all ingredients and admixtures if and as required.
- viii. Casting, curing, with steam/water as adopted, stacking at casting yard including all handling, re-handling and interim storage operations as required for precast girders.
- ix. Loading at casting yard, transportation to site in accordance with the prevailing traffic rules and regulations, unloading and stacking at site for precast girders.
- x. Provision of necessary & suitable packing to maintain the required gap between precast girders.
- xi. Protection of reinforcement, required to be left for Integration of the precast unit with top deck slab cast in place and bending the reinforcement to required shape after precasting & till their embedment in concrete.
- xii. Transporting precast segment to the location of placement, hoisting & placing in correct position, including all handling operations.
- xiii. The operation of placing precast segment over brackets/pier arms on teflon/neoprene pads/tar paper including the cost of all operations involved, appropriate setting of superstructure.
- xiv. Fixing/embedding any fixture supplied by the Employer.

- xv. The handling, carriage and storage of HT strands as per manufacturers' specification.
- xvi. The H.T. strands will be procured by the Contractor. The extra pieces of HT strands cut after the stressing of the cable will be the liability/property of the Contractor.
- xvii. Cost of all other items of materials, plants and equipment and works (not specifically excluded above) for proper prestressing operation of the strands in accordance with the provisions contained elsewhere in the tender documents will be included in the cost of this item.
- xviii. Providing/supplying and operating etc. of jacks and power pumps for prestressing, recording of data, tabulating the same in necessary formats for submission. The item will also include corrective measures that may be necessary and required by the Engineer.

6.3 Materials

6.3.1 Sheathing

Material for all pre-stressing sheathing duct shall be HDPE in the form of corrugated.

The Thickness of the HDPE sheathing ducts shall be as per conforming to IRS Concrete Bridge Code-1997 & IRC -112:2011, with modifications as stated below).

For Anchorage system 19 K K 15, HDPE ducts of 124mm OD/ 107mm ID (tolerance + 1mm) with minimum thickness of ducts 3.00 mm

For Anchorage system 12 K K 15, HDPE ducts of 100 mm OD/85 mm ID (tolerance + 1mm) with minimum thickness of ducts 2.50 mm

For Anchorage system 7 K K 15, HDPE ducts of 84 mm OD/69 mm ID (tolerance + 1mm) with minimum thickness of ducts 2.50 mm

The material for the ducts shall be high-density polyethylene with more than 2 percent carbon black to provide resistance to ultra-violet degradation and shall have the following properties:

Density (IS 2530)	:	0.94 – 0.96 g/cm ³ at 230C
Tensile Strength at yield (BS EN ISO 527-3)	:	20-26 N/mm ²
Shore Hardness D (BS EN ISO 2039-1)	:	3 sec – 60 min 15sec – 58min
Elongation at Yield (BS EN ISO 527-3)	:	7 % (min)
Melt Flow Index (MFI) (IS: 2530)	:	0.4 - 0.6 g / 10 minutes (Temperature 190° C under a mass of 5 kg.)

Charpy Impact strength of notched specimen (BS EN ISO 179)

At 23°C	:	10 kJ/m ²
-40°C	:	4 kJ/m ²

Coefficient of Thermal Expansion for 20°C – 80°C (DIN 53 752): 1.50×10^{-4} / °C

Environmental Stress Crack Resistance (ASTM D-1693) at 70°C: 192 Hrs

The residual wall thickness after loss (wear resistance) shall not be less than 1.5mm for ducts upto 85mm diameter and 2.mm for ducts diameter above 85mm as per IRC –112:2011.

The ducts shall be corrugated on both sides. The duct shall transmit full tendon strength from the tendon to the surrounding concrete over a length not greater than 40 duct diameters. Material and formulation of sheathing ducts shall conform to test and acceptance criteria of Appendix 1B of IRC: 18-2000.

These ducts shall be joined by adopting any one or more of the following methods, as convenient to suit the individual requirements of the location, subject to satisfactory pressure tests, before adoption.

- Screwed together with male and female threads.
- Joining with thick walled HDPE shrink couplers with glue. This can also be used for connection with trumpet, etc
- Welding with electro-fusion couplers.

The joints shall be able to withstand an internal pressure of 0.5 bar (0.05 MPa) for 5 minutes as per water loss test procedure given in Appendix-B of IRS Concrete Bridge Code-1997 (Addendum & corrigendum Slip No.5 Dated 19.11.2001).

The initial acceptance tests such as bond test; compression test are required to be performed as acceptance criteria for system. In addition to above, friction test as given in FIB bulletin. No-7 are also required to be performed as acceptance criteria. Test conducted by supplier in the past shall not be regarded as acceptance criteria.

The routine test such as workability test, transverse load rating test, tension load test and water loss test shall be applicable for both post threading and pre - threading system of cables. Loads to be imparted on the 107mm ID sheathing during transverse load rating test and tension load test shall be extrapolated from values given for smaller dia sheathing. At least 3 samples for one lot of supply (not exceeding 3000 metre length) shall be tested.

In viaduct constructed by precast segmental construction, cables shall be threaded after application of temporary prestressing. In continuous unit, constructed by cantilever construction techniques the cantilever cables will be stressed as various segments are cast progressively. Such cables shall be threaded after concreting. In such cases a temporary flexible PVC tube of 90 mm O.D shall be homed through sheathing which will provide adequate stiffness to sheathing during concreting and also prevent blockage of sheathing in case of possibility of leakage. The temporary PVC tube shall be pulled out before threading of the permanent cables.

6.4 Anchorages

6.4.1 Anchorages shall be procured from authorised manufacturers only. Anchorages shall conform to BS: 4447.

Load transfer test and anchorage efficiency shall be conducted as defined in FIP-1993. Engineer in-charge shall select at random, the required anchorage / wedges sample from completed lots for testing by the manufacturer. The concrete unit of required size/R/F will be made by contractor using same design mix of concrete which will be required for the load transfer test. The load transfer test shall be conducted at the strength of concrete at which stressing are proposed in the drawings.

No damaged anchorages shall be used. Steel parts shall be protected from corrosion at all times. Threaded parts shall be protected by greased wrappings and tapped holes shall be protected by suitable plugs until used. The anchorage components shall be kept free from mortar and loose rust and any other deleterious coating.

After completion of pre-stressing and grouting of cable in PSC girders, the extra length pre-stressing strands projecting outside the anchorage are required to be cut at the anchor end and anchor end is to be sealed.

Swages of prestressing strand shall develop strength of at least 95 per cent of the specified breaking load of the strand.

Un- tensioned Steel reinforcement, around anchorages shall be furnished by prestressing system supplier. Requirement of the same should be job specific and based on edge distance of anchorage and strength of concrete at the time of stressing of cables

as defined in drawings. The same R/F shall be provided in unit required for load transfer test.

Minimum 3 tests each are required to be conducted for load transfer test and anchorage efficiency test. The manufacturer shall complete the required testing and determine compliance the result with FIP-1993 recommendations before transporting the lot to site.

6.5 Prestressing Steel

Uncoated stress relieved low relaxation steel conforming to IS: 14268, class - 2 shall be used. Nominal dia shall be 15.2 mm with minimum breaking strength of 260.7 KN and minimum 0.2% proof load of 234.6 KN. various tests as recommended in IS: 14268 shall be conducted before transporting the lot to site. Apart from 1000 hrs relaxation test conducted by manufacturer, at least two such tests are required to be conducted by independent agency in the beginning of the project.

6.5.1 Prestressing Strands/Wires Storage

All high tensile steel for prestressing work shall be stored about 30cm above the ground in a suitably covered and closed space to protect it from dampness. It shall also be invariably wrapped in gunny cloth or tar paper or any other suitable material, as per approval of Engineer. Even if it is to be stored in an area at the site for the short time during transportation it shall be suitably covered. Protection during storage and repacking or application of washable protective coating to the H.T. steel shall be given by the contractor at no extra cost if the packing of H. T. Strand/wire during unloading and storage / handling in the stores gets damaged.

Stock piling of H. T. Steel on the work site shall not be allowed any time, especially before and during the monsoon.

Strand shall be stored in large diameter coils.

Engineer-in-Charge or his authorized representative shall always have an easy access to the store-yard for inspecting the H.T. Wire / strands / Bars and satisfying themselves regarding the condition thereof. Any modification regarding storage suggested by Engineer shall scrupulously be followed by the contractor. During monsoon days, H.T wires/strands shall be kept in reasonable air tight store, if required by the Engineer, at no extra cost.

6.6 Testing of Prestressing Steel and Anchorages

Contractor should submit friction and wobble coefficient of prestressing system proposed to be used. GFC will be based on the above data.

All materials specified for testing shall be furnished free of cost and shall be delivered in time for to be made well in advance of anticipated time of use.

All strands to be transported to the site shall be assigned a lot number and tagged for identification purposes. Anchorage assemblies to be transported shall be like-wise identified.

All samples submitted shall be representative of the lot to be furnished and in the case of strand, shall be taken from the same master roll. The Contractor shall furnish samples of at least 5.0m length selected from each lot for testing. Also, two anchorage assemblies, complete with distribution plates of each size or type to be used, shall be furnished along with short lengths of strands as required.

All equipment must be used in accordance with the specification of the manufacturer and must at all times be maintained in good condition.

The type of jack used should correspond with the type of strand used. It must also be checked that the jacks have the necessary stroke for the stressing of the strands/wires on the particular job. Pressure tests on jacks must be executed with pressures 10% higher than the maximum operating pressure. The combined jack and pump system should be checked for correct behavior.

6.7 Workmanship

6.7.1 Cleaning

Tendons shall be free from loose rust, oil, grease, tar, paint, mud or any other deleterious Substance.

Cleaning of the steel may be carried out by immersion in suitable solvent solutions, wire brushing or passing through a pressure box containing carborundum powder. However, the tendons shall not be brought to a polished condition.

6.7.2 Straightening

High tensile strand shall be supplied in coils of sufficiently large diameter such that tendons shall retain their physical properties and shall be straight as it unwinds from the coil. Tendons of any type that are damaged, kinked or bent shall not be used.

The packing of prestressing strand shall be removed only just prior to making of cable for placement. Suitable stands shall be provided to facilitate uncoiling of strands without damage to steel. Care shall be taken to avoid the possibility of steel coming into contact with the ground.

6.7.3 Positioning

i. Post-Tensioning

- Prestressing tendons shall be accurately located and maintained in position, both vertically and horizontally, as per drawings.
- Tendons shall be so arranged that they have a smooth profile without sudden bends or kinks. Pull-in or push-in of the prestressing strands shall be mechanized,
- The location of prestressing cables shall be such as to facilitate easy placement and vibration of concrete in between the tendons.
- Sheathing shall be placed in correct position and profile by providing suitable ladders and spacers. Such ladders may be provided at intervals of approximately 1.0 m. Sheathing shall be tied rigidly with such ladders/spacer bars so that they do not get disturbed during concreting.
- The method of supporting and fixing shall be such that profile of cables is not disturbed during vibrations, by pressure of wet concrete, by workmen or by construction traffic.
- Each anchorage device shall be set square to the line of action of the corresponding prestressing tendon and shall be positioned securely to prevent movement during concreting.
- The anchorage devices shall be cleaned to the satisfaction of the Engineer prior to the placing of concrete. After concreting, any mortar or concrete, which adheres to bearing or wedging surfaces, shall be removed immediately.

6.7.4 Cutting

Cutting and trimming of wires or strands shall be done by suitable mechanical or flame cutters. When a flame cutter is used, care shall be taken to ensure that the flame

does not come in contact with other stressed steel. The location of flame cutting of strand shall be kept beyond 75 mm of where the tendon will be gripped by the anchorage or jacks.

In post-tensioning, the ends of prestressing steel projecting beyond the anchorages shall be cut after the grout has set.

6.7.5 Protection of Prestressing Steel

- Prestressing steel shall be continuously protected against corrosion, until grouted. The corrosion protector shall have no deleterious effect on the steel or concrete or on the bond strength of steel to concrete. Grouting shall conform to these specifications or as directed by the Engineer.

6.7.6 Sheathing

- The joints of all sheathings shall be water-tight. Special attention shall be paid to the junction at the anchorage end, where the sheathing must tightly fit on the protruding trumpet end of anchorage and thereafter sealed preferably with adhesive water proof tape as per approved manufacturer.
- The sheathing and all joints shall be water-tight. Any temporary opening in the sheathing shall be satisfactorily plugged and all joints between sheathing and any other part of the prestressing system shall be effectively sealed to prevent entry of mortar, dust, water or other deleterious matter. Sheathing shall be neatly fitted at joints without internal projection or reduction of diameter.
- Enlarged portions of the sheathing at couplings or anchorages shall be of sufficient length to provide for the extension of the tendons.

6.7.7 Grout Vents

Grout vents of at least 20 mm diameter shall be provided at both ends of the sheathing and at all valleys and crests along its length. Additional vents with plugs shall also be provided along the length of sheathing such that the spacing of consecutive vents do not exceed 20m. Each of the grout vents shall be provided with a plug or similar device capable of withstanding a pressure of 1.0 MPa without the loss of water, air pressure or grout

6.7.8 Anchorages

All bearing surfaces of the anchorages shall be cleaned prior to concreting and tensioning. Anchor cones, blocks and plates shall be securely positioned and maintained during concreting such that the centre line of the duct passes axially through the anchorage assembly.

The anchorages shall be recessed from the concrete surface as per drawings.

After the prestressing operations are completed and prestressing strands are cut, the surface shall be painted with two coats of epoxy of suitable formulation having a dry film thickness of 80 microns per coat and entire recess shall be filled with concrete or non-shrink/pre-packaged mortar or epoxy concrete.

6.7.9 Handling and Storage

Care shall be taken to avoid mechanically damaging, work-hardening or heating prestressing tendons while handling. All prestressing tendons shall be stored clear of the ground and protected from the weather, from splashes from any other materials, and from splashes from the cutting operation of an oxy-acetylene torch, or arc-welding processes in the vicinity.

In no circumstances shall prestressing tendons after manufacture be subjected to any welding operation, or 'on-site' heat treatment or metallic coating such as galvanising. This does not preclude cutting as specified.

All wires, strands or bars stressed in one operation shall be taken, where possible, from the same parcel. Each cable shall be tagged with its number from which the coil numbers of the steel used can be identified. Cables shall not be kinked or twisted. Individual wires and strands for which extensions are to be measured shall be readily identifiable at each end of the member. No strand that has become unraveled shall be used.

6.7.10 Supervision

All prestressing and grouting operations shall be undertaken by trained personnel only. A representative of supplier of the prestressing system shall be present during all tensioning and grouting operations and shall ensure, monitor and certify their correctness.

6.8 Post-Tensioning

Tensioning force shall be applied in gradual and steady steps and carried out in such a manner that the applied tensions and elongations can be measured at all times. The sequence of stressing, applied tensions and elongations shall be in accordance with the approved drawing or as directed by the Engineer.

It shall be ensured that in no case, the load is applied to the concrete before it attains the strength specified on the drawing or as stipulated by the prestressing system supplier, whichever is more.

After prestressing steel has been anchored, the force exerted by the tensioning equipment shall be decreased gradually and steadily as to avoid shock to the prestressing steel or anchorage.

The tensioning force applied to any tendon shall be determined by direct reading of the pressure gauges or dynamo-meters and by comparison of the measured elongation with the calculated elongation. The calculated elongation shall be invariably adjusted with respect to the modulus of elasticity of steel for the particular lot as given by the manufacturer.

Parallel measurement of prestressing force by load cell in combination with direct reading of pressure gauge shall be preferred. In any case such parallel measurements by load cell shall be made for at least 10% of the cables stressed during any tensioning operation

The difference between calculated and observed tension and elongation during prestressing operations shall be regulated as follows:

- a) If the calculated elongation is reached before the specified gauge pressure is obtained, continue tensioning till attaining the specified gauge pressure, provided the elongation does not exceed 1.05 times the calculated elongation. If 1.05 times the calculated

elongation is reached before the specified gauge pressure is attained, stop stressing and inform the Engineer.

- b) If the calculated elongation has not been reached at the specified gauge pressure, continue tensioning by intervals of 5kg/sq.cm until the calculated elongation is reached provided the gauge pressure does not exceed 1.05 times the specified gauge pressure.
- c) If the elongation at 1.05 times the Specified gauge pressure is less than 0.95 times the calculated elongation, the following measures must be taken, in succession, to determine the cause of this discrepancy:
 - i) Check the correct functioning of the jack, pump and leads.
 - ii) Detention the cable. Slide it in its duct to check that it is not blocked by mortar which has entered through holes in the sheath. Retension the cable if free.
 - iii) Re-establish the modulus of elasticity of steel for the particular lot from an approved laboratory. Contractor may suggest other remedial measure for approval of the Engineer. If the required elongation is still not obtained, further finishing operations as cutting or sealing, should not be undertaken without the approval of the Engineer.
- d) When stressing from one end only, the slip at the end remote from the jack shall be accurately measured and an appropriate allowance made in the measured extension at the jacking end.

A complete record of prestressing operations along with elongation and jack pressure data shall be maintained in the format given in Appendix 1800/II of MORT&H Specification.

- e) Any breakage of individual strand / groups of strands during tensioning shall require immediate destressing of all strands and replacement of the all the strands by fresh strands.

6.9 Grouting of Prestressed Tendons

Prior to grouting, all cables shall be tested with water pressure of 0.5 Bar (0.05 MPa) for approximately 5 minutes, to investigate leakages and connectivity of ducts. Where directed by the Engineer, the Contractor shall perform full scale site test to determine the adequacy of grout mix, equipment and grouting method. The Contractor shall submit a method statement detailing the test procedure.

All other aspects of grouting of cables shall be governed by. MORTH Specifications. A record of grouting operations shall be maintained in the format as given in Appendix 1800/IV of MORTH Specifications.

Handling and Storage

Care shall be taken to avoid mechanically damaging, work-hardening or heating prestressing tendons while handling. All prestressing tendons shall be stored clear of the ground and protected from the weather, from splashes from any other materials, and from splashes from the cutting operation of an oxy-acetylene torch, or arc-welding processes in the vicinity.

In no circumstances shall prestressing tendons after manufacture be subjected to any welding operation, or 'on-site' heat treatment or metallic coating such as galvanising. This does not preclude cutting as specified.

All wires, strands or bars stressed in one operation shall be taken, where possible, from the same parcel. Each cable shall be tagged with its number from which the coil numbers of the steel used can be identified. Cables shall not be kinked or twisted. Individual wires and strands for which extensions are to be measured shall be readily identifiable at each end of the member. No strand that has become unraveled shall be used.

All prestressing and grouting operations shall be undertaken by trained personnel only. A representative of supplier of the prestressing system shall be present during all tensioning and grouting operations and shall ensure, monitor and certify their correctness.

6.10 Tensioning Equipment

The tensioning apparatus shall meet the following general requirements: -

- i. The means of attachment of the tendon to the jack or tensioning device shall be safe and secure.
- ii. Where two or more wires or strands are stressed simultaneously, they shall be approximately of equal length between anchorage points at the datum of load and extension measurement. The degree of variation shall be small compared with the expected extension.
- iii. The tensioning apparatus shall be such that a controlled total force is imposed gradually and not dangerous secondary stresses are induced in the tendons, anchorage or concrete.
- iv. The force in the tendons during tensioning shall be measured by direct-reading load cells or obtained indirectly from gauges fitted in the hydraulic system to determine the pressure in the jacks. Facilities shall be provided for the measurement of the extension of the tendon and of any movement of the tendon in the gripping devices. The load-measuring device shall be calibrated to an accuracy within $\pm 2\%$ and checked at intervals to the approval of the Engineer. Elongation of the tendon shall be measured to an accuracy within 2% or 2 mm, whichever is the more accurate.
- v. The tensioning equipment shall be calibrated before the tensioning operation and at intervals of the months or as approved by the Engineer. Any indication in the loss of strength in tendons during the tensioning operation shall be brought to the attention of the Engineer. Any corrective measures which may be required in procedures and/or material shall be approved by the Engineer.

When friction must be reduced, water soluble oil may be used subject to the approval of the Engineer. This oil may be flushed from the duct as soon as possible after stressing is completed by use of water pressure. These ducts shall be flushed again just prior to the grouting operations. Each time the ducts are flushed, they shall be immediately blown dry with oil-free air.

6.11 Testing by Contractor

For the purpose of accurately determining the tendon elongations while stressing, the Contractor shall bench test two samples of each size and type of strand tendon to determine the modulus of elasticity prior to stressing the initial tendon. The bench should be at least 6 metres long, with concrete anchorage blocks having a constant area end section of at least four times that of the anchorage assembly area. The tendon shall be straight and centered on the cross-sectional area of the bench. The test procedure shall consist of stressing the tendon at an anchor assembly with the dead end consisting of a

load cell. The test specimen shall be tensioned to 80 percent of ultimate to 0 in 10 increments. For each increment, the gauge pressure, elongation and load cell force shall be recorded. The data shall be furnished to the Engineer. The theoretical elongations shown on the post-tensioning working drawings shall be reevaluated by the Contractor using the results of the tests and corrected as necessary. Revisions to the theoretical elongations shall be submitted to the Engineer for approval. Apparatus and methods used to perform the tests shall be proposed by the Contractor and be subject to the approval of the Engineer. After the initial testing, five (5) more tests shall be performed. These tests shall be spaced evenly throughout the duration of the Contract.

6.12 Pretensioning

Where pretensioning methods are used, the tension shall be fully maintained by some positive means during the period between tensioning and transfer. The transfer of stress shall take place slowly to minimize shock.

i. Straight Tendons

In the long line method of pretensioning, sufficient locator plates shall be distributed throughout the length of the bed to ensure that the wires or strands are maintained in their proper position during concreting. Where a number of units are made in the line, they shall be free to slide in the direction of their length and thus permit transfer of the prestressing force to the concrete along the whole line.

In the individual mould system, the moulds shall be sufficiently rigid to provide the reaction to the prestressing force without distortion.

ii. Deflection Tendons

Where possible the mechanisms for holding down or holding up tendons shall ensure that the part in contact with the tendon is free to move in the line of the tendon so that frictional losses are nullified. If, however, a system is used that develops a frictional force, this force shall be determined by test and due allowance made as agreed by the Engineer.

For single tendons the deflector in contact with the tendon shall have a radius of not less than 5 times the tendon diameter for wire or 10 times the tendon diameter for a strand, and the total angle of deflection shall not exceed 15° . Where the radius is less than 5 times the diameter of the tendon and the angle of deflection exceed 15° , the loss of strength of the tendon shall be determined by test and due allowance made.

The transfer of the prestressing force to the concrete shall be affected in conjunction with the release of hold-down and hold-up forces as approved by the Engineer.

6.13 Pre Tensioning

- Pre-stressing strands shall be of diameter as per drawing, uncoated stress relieved low relaxation steel & from approved source
- Stock piling of HT Strands at site shall not be done especially during before & after monsoon season.
- HT Strands shall be stored about 30cm above the ground in a suitably covered & closed space to protect it from dampness.
- It shall also be wrapped with any suitable material for its protection against moisture & unwanted materials.
- The number of uncoated strands shall be placed in the reinforcement cage as per the span length mentioned in the approved drawings.

- In a number of strands, the number of fully bonded and partially bonded strands shall be identified as per the drawings.
- The partially bonded strands shall be a set of strands having a de-bonded length that shall be measured from the face of recess at the end of the pre cast element.
- The length of de-bonded strands from recess face shall be as per approved drawings.
- Strands shall be initially stressed with small pre-stressing force to remove slackness of the strands.
- After removal of slackness, strands & de-bonding tubes shall be thoroughly examined to ensure correct alignment.
- The strands shall be stressed at the stressing force as approved.
- Stressing shall be done with Stressing jacks by approved stressing agency.
- Stressing of strands shall be done either by single pull or multi pull jack, in case of single pull jack it shall be ensured that the strands shall be stressed symmetrically with respect to the centre line of the pre cast element.
- Stressing with multi pull jack shall also be done in proper sequence so that the transfer of stresses to concrete portion shall be uniform.
- A complete record of prestressing operations along with elongation and jack pressure data shall be maintained in the format given in MORT&H Specification

6.14 Post-tensioning

i. Arrangement of Tendons

Where wires, strands or bars in a tendon are not stressed simultaneously, the use of spacers shall be in accordance with the recommendations of the system manufacturer.

ii. Anchorages

- a) Anchorages shall be tested in accordance with the requirements of BS 4447.
- b) For each anchorage system used in the Works, the characteristic value for anchorage efficiency shall be not less than 90%.
- c) Proprietary anchorages shall be handled and used strictly in accordance with the manufacturer's instructions and recommendations.

iii. Deflected Tendons

The deflector in contact with the tendon shall, have a radius of not less than 50 times the diameter of the tendon, and the total angle of deflection shall not exceed 15 degrees unless otherwise agreed by the Engineer.

iv. Tensioning Procedure

Before tensioning, the Contractor shall demonstrate that all tendons are free to move in the ducts unless the geometry of the ducts makes this impracticable as agreed by the Engineer. Tensioning shall be carried out in such a manner that the stress in the tendons increases at a gradual and steady rate.

Unless otherwise described in the Contract, concrete shall not be stressed until it has reached at least the age at which 2 test cubes taken from it attain the specified transfer strength. The test cubes shall be made and tested as described in BS 1881. They shall be cured in similar conditions to the concrete to which they relate in a manner approved by the Engineer.

The Contractor shall cast sufficient cubes to demonstrate that the required strength of the concrete at transfer has been reached.

The Contractor shall ensure that those carrying out the stressing are provided with particulars of the required tendon loads, order of stressing and extensions. Allowance

shall be made during stressing for the friction in the jack and in the anchorage, although the former is not necessary when using load cells.

Any allowance for draw-in of the tendon during anchoring shall be in accordance with the Engineer's instructions.

Stressing shall continue until the required extension and tendon load are reached or are approved by the Engineer.

The extension shall allow for any draw-in of the tendon occurring at the non-jacking end, but measurement shall not commence until any slack in the tendon has been taken up.

Immediately after anchoring, the forces in the prestressing tendons shall not exceed 70% of their characteristic strength. During stressing the value may exceed 70% of their characteristic strength, with the approval of the Engineer, but shall not exceed 80%.

After the tendons have been anchored, the force exerted by the tensioning apparatus shall be decreased gradually and steadily so as to avoid shock to the tendon or the anchorage.

Full records shall be kept of all tensioning operations, including the measured extensions, pressure-gauge or load-cell readings, and the amount of draw-in at each anchorage. Copies of these records shall be supplied to the Engineer within 24 hours of each tensioning operation.

Unless otherwise agreed by the Engineer tendons shall not be cut less than 3 days after grouting.

6.15 Prestressing Tendons - Protection and Bond

The prestressing tendons shall be protected in their permanent positions from both mechanical damages shall be applied to all unbounded prestressing tendons within 28 days of installation of the tendon in the duct.

The tendon protection compound applied to the and corrosion as described in the Contract and the following sub-clauses.

The exposed tendons at the anchorages and the anchorages themselves shall be sealed within a closed box and protected from both mechanical damage and corrosion. Suitable access shall be left for jacking equipment for the later removal of the strands of unbounded tendons. The means of protection shall be designed by the prestress supplier and approved by the Engineer.

A tendon protection compound tendon shall be a micro-crystalline wax (petrolatum) base material containing additives to enhance the corrosion inhibiting, wetting, and moisture displacing properties, as well as the ability to form a polar bond with the tendon steel.

The compound Manufacturer shall provide test data verifying that the following properties are met for the service life of 120 years and temperature range of 0°C to 50°C evaluation and acceptance by the Engineers:

- (a) freedom from cracking and brittleness;
- (b) continuous self-healing film over the coated surfaces;
- (c) chemical and physical stability;
- (d) non reactivity with the surrounding and adjacent materials such as concrete, tendons, and ducts;

(e) moisture displacing characteristics.

Additionally, it shall remain flexible to allow removal and replacement of the tendons. The tendon protection compound and its method of installation shall be approved by the Engineer.

Provision shall be made for expansion of the tendon protection compound during the lifetime of the structure.

Before installing the tendon protection compound it shall be demonstrated that the ducts, U-bend anchorage and anchorages are clean and free of water and chlorides.

The tendons, internal face of the steel u-bend anchorage, stressing anchorages and any other metallic components of the prestressing system shall additionally be pre-treated with a protection compound before delivery to site. The protection compound shall be applied to each strand of the tendon and shall be compatible with the tendon protection compound injected into the ducts. The protection compound shall be approved by the Engineer.

The supplier of the tendon protection compound shall submit for the Engineer's approval proposals which shall describe how the tendon protection compound can be removed and re-injected into ducts, including buried ducts, within the permanent works.

All materials used in the prestressing systems shall not give off toxic fumes at temperatures below 50°C and shall not support combustion.

6.16 Ducts for Bonded Tendons

Ducts for longitudinal, transverse or vertical tendons embedded into the concrete may be of flexible, semi-rigid, or rigid galvanized, ferrous metal capable of withstanding concrete pressures without deforming or permitting the entrance of cement paste during casting of the member. They must retain their shape and be capable of transferring bond stresses. The semi-rigid duct must be rigid enough to remain straight when supported at 1200 mm maximum intervals but flexible enough to allow 3600 mm radius curves. Flexible duct shall be secured or supported at not more than 300 mm intervals.

6.17 Grouting of Prestressing Tendons

1. General

The Contractor shall undertake grouting trials when required by the Engineer.

2. Materials

Unless otherwise directed or agreed by the Engineer as a result of grouting trials, the grout shall consist only of Ordinary Portland.

Cement and water. The water/cement ratio shall be as low as possible consistent with the necessary workability, and under no circumstances shall the W/C ratio exceed 0.45 by weight.

The grout shall not be subject to bleeding in excess of 2% after 3h or 4% maximum when measured at 25°C or such other temperature as may be approved by the Engineer, in a covered cylinder approximately 10mm diameter with a height of grout of approximately 100 mm, and the water shall be reabsorbed by the grout during the 24h after mixing.

Admixtures may be used with the written permission of the Engineer and shall be applied strictly accordance with the manufacturer's instructions. Admixtures shall not contain chloride ions in excess of 0.25 percent by weight. Dry materials shall be measured by weight.

Dry materials shall be measured by weight.

3. Ducts

Air vents shall be provided at any crests in the duct profile and elsewhere as specified. All ducts shall be thoroughly clean before grouting. Ducts formed without metal sheathing shall be provided with effective drainage and, unless otherwise directed by the Engineer, shall be flushed with water before grouting. All surplus water shall be removed by compressed air injection. All anchorages shall be sealed or fitted with grouting connections.

4. Grouting Equipment

The mixing equipment shall produce a grout of homogeneous consistency and shall be capable of providing a continuous supply to the injection equipment. The injection equipment shall be capable of continuous operation with little variation of pressure and shall include a system for recirculating the grout while actual grouting is not in progress. Compressed air shall not be used.

The equipment shall have a sensibly constant delivery pressure not exceeding 1 N/mm². All piping to the grout pumps shall have a minimum of bends, valves and changes in diameter. All baffles to the pump shall be fitted with 1.18 mm sieve strainers. All equipment, especially piping, shall be thoroughly washed through with clean water after every series of operations and at the end of use for each day. The interval between washing shall not exceed 3h.

The equipment shall be capable of maintaining pressure on completely grouted ducts and shall be fitted with a valve that can be locked off without loss of pressure in the duct.

5. Mixing

Water shall be added to the mixer first, then the cement. When these are thoroughly mixed, the admixture, if any, shall be added. Mixing shall continue until a uniform consistency is obtained. Mixing shall not be by hand. The temperature of the grout shall be maintained as per specifications.

6. Injecting Grout

Grouting shall be carried out as soon as is practicable after the tendons in them have been stressed and anchors trimmed and the Engineer's permission to commence has been obtained. Injection shall be continuous, and it shall be slow enough to avoid producing segregation of the grout. The method of injecting grout shall ensure complete filling of the ducts and complete surrounding of the steel. Grout shall be allowed to flow from the free end of the duct until its consistency is equivalent to that of the grout injected. The opening shall then be firmly closed. Any vents shall be closed in a similar manner one after another in the direction of the flow. After an appropriate time, further injections shall be carried out to fill any possible cavities.

The injection tubes shall then be sealed off under pressure until the grout has set.

The filled ducts shall not be subjected to shock or vibration within 1 day of grouting.

Not less than 2 days after grouting, the level of grout in the injection and vent tubes shall be inspected and made good as necessary.

The Contractor shall keep full records of grouting including the date each duct was grouted, the proportion of the grout and any admixtures used, the pressure, details of any interruptions and topping up required. Copies of these records shall be supplied to the Engineer within 3 days of grouting.

Where required by the Engineer, the Contractor shall provide facilities and attendance for the radiographic testing of duct.

7. Strength of Grout

The compressive strength of 100 mm cubes made of the grout shall exceed 17 N/mm² at 7 days. Cubes shall be cured in a moist atmosphere for the first 24h, and subsequently in water.

6.18 Ducts for Unbonded Tendons

Unless shown otherwise on the Drawings, ducts and injection tubes in the superstructure and substructure shall be formed from high density polyethylene (HDPE) which shall incorporate a stabilizing agent to prevent Ultra Violet Light (UVL) degradation.

The minimum wall thickness of the ducts shall be such that the ducts are capable of resisting the pressures developed during installation of the protection compound. The ducts shall be smooth bore.

Ducts with external diameters greater than 70 mm shall be transported and stored in straight lengths. The distance between supports shall be limited to 3m and the height of storage to 1.5 m. Alternatively, ducts may be transported and stored in coils provided that they are fixed to the tolerances required by the Designer.

Damaged ducts shall not be used in the Works.

No boring of any No boring holes in the ducts shall be permitted once the tendons are installed.

U-bend anchorages shall be formed from smooth-bore unwelded steel tubes and shall comply with the requirements of BS 4360.

Joints between ducts, ducts and anchorages and ducts and U-bend anchorages shall be formed by a coupling device using thermo-fusion techniques which shall provide a watertight seal to the ducts and shall be capable of resisting the pressure developed during installation of the tendon protection compound. The inner surfaces of the joints shall form a smooth transition between ducts and U-bend anchorages to allow satisfactory installation of the tendons. All coupling devices shall be approved by the Engineer.

Injection tubes shall be provided at the U-bend anchorages, the stressing anchorages and at any other positions on the length of the ducts which are required to achieve satisfactory installation of the tendon protection compound. The injection tubes at the U-bend anchorages shall also be used as drainage points for the U-bend. The connection between the ducts and the injection tubes shall be watertight and capable of resisting the pressure developed during installation of the tendon protection compound.

All injection tubes shall be sealed after use to prevent the ingress of water to the satisfaction of the Engineer.

After completion of all duct joints and before completion of the insitu joints between precast segments and before installation of the tendons, all ducts shall be air tested to an equivalent 100 mm water gauge unless otherwise directed by the Engineer. The test shall be performed in accordance with BS 8301 Section 5.

Any ducts which do not contain tendons shall remain empty and shall be sealed at each end to prevent the ingress of water.

6.19 Prestressing Tendons - Trial Construction-Unbonded Tendons

Before commencing construction of the precast segments, a trial shall be carried out which shall demonstrate the satisfactory installation, removal and replacement of a prestressing strand together with the proposed techniques for duct jointing, duct testing and installation of the tendon protection compound.

- i. The tendons shall be stressed in accordance with this Specification.
- ii. The ducts shall be filled with a tendon protection compound in accordance with the specification as detailed in relevant subsections and the tendon extension and anchorage shall be protected as if they were to be included in the permanent works.
- iii. The trial shall demonstrate that any one strand may be destressed, removed, inspected, replaced and re-stressed and that no voids are created within the tendon protection compound, all to the satisfaction of the Engineer.
- iv. The trial shall also demonstrate that all of the strands in a duct may be removed and that the tendon protection compound can be removed from the ducts and U-bend anchorage to the satisfaction of the Engineer.
- v. The trial shall be undertaken using the prestressing system to be used in the permanent works and shall be approved by the Engineer.

Prestressing Tendons - Temporary Tendons

Temporary tendons may be re-used as temporary tendons elsewhere provided special precautions are incorporated at the anchorages to ensure tendons are not damaged. These precautions shall be approved by the Engineer.

The tendons shall be enclosed within a duct throughout their length.

The tendons shall be pre-treated in accordance with the specifications as detailed in relevant subsections and the protection compound shall be applied to the outer surfaces of the tendon after each use.

The maximum jacking force for the re-usable temporary tendons shall not exceed 70 percent of their guaranteed minimum breaking load.

After removal of the tendons the ducts shall be sealed at each end to prevent the ingress of water.

6.20 Preparation for Casting

- a) The Contractor shall submit for approval, in accordance with the provisions of the Employer's Requirements, working drawings of the prestressing system proposed for use. For initial review, 3 sets of such drawings shall be submitted.
- b) After review, between 6 and 12 sets, as requested by the Engineer, shall be submitted for final approval and for use during construction.

- c) The working drawings of the prestressing system shall show complete details and be accompanied by substantiating calculations of the method and materials the Contractor proposes to use in the prestressing operations, including any additions or rearrangement of reinforcing steel from that shown on the Drawings. Such details shall outline the method and sequence of stressing and shall include complete specifications and details of the prestressing steel and anchoring devices, working stresses, anchoring stresses, type of ducts, and all other data pertaining to the prestressing operation, including the proposed arrangement of the prestressing steel in the members.
- d) Working drawings shall be A1 size and each drawing and calculation sheet shall include the job site, name of the structure as shown on the Contract Drawings and Contract name.
- e) Working drawings shall be submitted sufficiently in advance of the start of the affected work to allow time for review by the Engineer and correction by the Contractor of the drawings without delaying the work. Such time shall be proportional to the complexity of the work but in no case shall such time be less than eight (8) weeks.
- f) At the completion of each structure, one set of reproducible mylars of the corrected original tracing of all working drawings for said structure shall be furnished to the Engineer. Drawings which are common to more than one structure shall be provided for each structure. An index prepared specifically for the drawings for each structure containing sheet numbers and titles shall be included.
- g) Reinforcing steel shall be fabricated and placed in accordance with the Drawings. and as required herein. No reinforcing steel shall be cut and removed to permit proper alignment of stressing ducts. Any bar that cannot be fabricated to clear the conduits shall be replaced by additional bars with adequate lap lengths and shall be submitted to the Engineer for approval. In the plane of the steel parallel to the nearest surface of concrete, bars shall not vary from plan placement by more than 12 mm or one-tenth (1/10) of the spacing between bars, whichever is less.
- h) All prestressing steel shall be protected against physical damage and rust or other results of corrosion at all times from manufacture to grouting or encasing in concrete. Prestressing steel that has sustained physical damage at any time shall be rejected. The development of visible rust or other results of corrosion shall be cause for rejection, when ordered by the Engineer.
- i) Prestressing steel shall be packaged in containers or shipping forms for the protection of the steel against physical damage and corrosion during shipping and storage. A corrosion inhibitor which prevents rust or other results of corrosion shall be placed in the package or form, or shall be incorporated in a corrosion inhibitor carrier type packaging material, or when permitted by the Engineer, may be applied directly to the steel. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete. packaging or forms damaged from any cause shall be immediately replaced or restored to original condition.
- j) The shipping package or form shall be clearly marked with a statement that the package contains high-strength prestressing steel, and the care to be used in handling; and the type, kind and amount of corrosion inhibitor used, including the date when placed, safety orders and instructions for use.
- k) Prestressing steel for post-tensioning which is installed in members prior to placing and curing of the concrete, shall be continuously protected against rust or other corrosion,

until grouted, by means of a corrosion inhibitor placed in the ducts or applied to the steel in the duct. The corrosion inhibitor shall conform to the requirements specified herein.

- l) When steam curing is used, prestressing steel for post-tensioning shall not be installed until the steam curing is completed.
- m) All water used for flushing ducts shall contain either quick lime (calcium oxide) or slaked lime (calcium hydroxide) in the amount of 13g. per litre. All compressed air used to blow out ducts shall be oil free.
- n) When acceptable prestressing steel for post-tensioning is installed in the ducts after completion of concrete curing, and if stressing and grouting are completed within 10 calendar days after the installation of the prestressing steel, rust which may form during said 10 days will not be cause for rejection of the steel. Prestressing steel installed, tensioned and grouted in this manner, all within 10 calendar days, will not require the use of a corrosion inhibitor in the duct following installation of the prestressing steel. Prestressing steel installed as above but not grouted within 10 calendar days shall be subject to all the requirements in this section pertaining to corrosion protection and rejection because of rust.
- o) Any time acceptable prestressing steel for pretensioning is placed in the stressing bed and is exposed to the elements for more than 36 hours prior to encasement in concrete, adequate measures shall be taken by the Contractor, as approved by the Engineer, to protect said steel from contamination or corrosion.
- p) All ducts shall be located within 5 mm of the locations given on approved fabrication plans. Method and spacing of supports for ducts shall be shown on the working drawings. After installation in the forms, the end of the ducts shall at all times be sealed to prevent entry of water and debris. Following each pour of concrete, the Contractor will be required to demonstrate that all empty ducts are free of water and are unobstructed and undamaged. Immediately prior to installation of the prestressing steel, the Contractor shall again demonstrate to the satisfaction of the Engineer that all ducts are unobstructed and that they are free of water and debris.

Where tendons are described in the Contract as debonded from the concrete they shall be covered with sleeves approved by the Engineer. The ends of the sleeves shall be taped to the tendon to prevent the ingress of grout.

- q) Concrete shall not be deposited into forms until the entire set-up of the forms, reinforcement, ducts, and anchorage has been thoroughly inspected and checked. The placing of concrete will not be permitted until the Engineer is satisfied that the rate of producing and placing concrete will be sufficient to complete the proposed pour and finishing operations within the scheduled time, that experienced concrete finishers are available where required for finish work and all necessary finishing tools and equipment are on hand at the site of the work and are in satisfactory condition for use.
- r) Conveying equipment shall be of a size and design that will permit the placing of concrete within the time limits specified. Conveying equipment shall be cleaned at the end of each operation or work day and just prior to reuse shall again be checked and cleaned of hardened concrete and foreign materials. Belt conveyors shall be horizontal or at a slope which will not cause excessive segregation or loss of ingredients. Concrete shall be protected against undue drying or rise in temperature. An approved arrangement shall be used at the discharge end to prevent aggregate

segregation. Mortar shall not be allowed to adhere to the return length of the belt. Concrete shall be discharged into a hopper or through a baffle.

- s) The concrete shall be first placed in the web forms followed by placement at the bottom slab and then in the top form. Any alternate sequence shall be submitted to the Engineer for approval.
- t) All concrete shall be consolidated by means of approved vibrators together with any other equipment necessary to perform the work as specified. Internal vibrators shall have a minimum frequency of 8,000 vibrations per minute and sufficient amplitude to consolidate the concrete effectively. At least two (2) standby vibrators in working condition shall be provided for emergency use in case of malfunction. The use of external vibrators for consolidating concrete will be permitted and may be required when the concrete is inaccessible for adequate consolidation. When external vibration is used, the forms shall be constructed sufficiently rigid to resist displacement or damage. Vibrating of concrete shall be done with care and in such a manner as to avoid displacement of reinforcing, conduits, and other items to be fixed in place.

6.21 Safety Precautions During Tensioning

Care shall be taken during tensioning to ensure the safety of all persons in the vicinity.

Jacks shall be secured in such a manner that they will be held in position, should they lose their grip on the tendons.

No person shall be allowed to stand behind the jacks or close to the line of the tendons while tensioning is in progress.

The operations of the jacks and the measurement of the elongation associated operations shall be carried out in such a manner and such a position that the safety of all concerned is ensured.

A safety barrier shall be provided at both ends to prevent any tendon, which might become loose from recoiling unchecked.

During actual tensioning operation, warning sign shall be displayed at both ends of the tendon.

After prestressing, concrete shall neither be drilled nor any portion cut nor chipped away nor disturbed, without express approval of the Engineer.

No welding shall be permitted on or near tendons nor shall any heat be applied to tendons. Any tendon which has been affected by welding, weld spatter or heat shall be rejected.

6.22 Tolerances

Permissible tolerances for positional deviation of Prestressing tendons in cast-in-situ construction shall be limited to the following

- a) Variation from the specified horizontal profile : 5 mm
- b) Variation from the specified vertical profile : 5 mm
- c) Variation from the specified position in member : 5 mm

6.23 Transportation and Storage of Unit:

Precast members shall be transported in an upright position. Points of support and the direction of reactions with respect to the girder shall approximately be the same during transportation, and storage as when the girder is placed in final position.

When members are to be stacked, they shall be firmly supported at such bearing positions as will ensure that the stresses induced in them are always less than the permissible design stresses. Further, inclined side supports shall be provided at the ends and along the length of a precast girder to prevent lateral movements or instability.

Care shall be taken during storage, hoisting and handling of the precast units to prevent their cracking or being damaged. Units damaged by improper storing or handling shall be replaced by the Contractor at his expense

6.24 Tests and Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

Shop drawings and design calculations for construction procedure needs to be submitted by the contractor

6.25 Measurement

The measurement for prestressing steel wires shall be made change in procedure on the actual length of wires from end to end of cut-face of anchorages for post tensioned concrete as per the profile drawing and shall not include the extra length of wires at both ends. For pretensioned concrete the measurements of high tensile steel wires shall be measured from end to end of concrete faces and shall not include extra length of wires at both ends. The rates for high tensile steel work shall include formation of cables in position including cost of spacers, transporting, anchorages, sheathing, grouting, stressing and all other relevant work including staging etc.

SECTION- S.07

7. STRUCTURAL STEEL WORKS

7.1 General

These specifications shall be read in conjunction with the CPWD specifications 2009 and other relevant reference specifications described in the section 1 of these specifications.

The Contractor will provide all materials and equipment required to complete the works in every respect, whether such materials are required as part of the permanent structures or temporary for fabrication or erection or maintenance including specifically structural steel plates, flats, bars, welding rods, rivets, bolts and nuts, paint, welding sets in the shop and at site, all workshop facilities, derricks, cranes, pulley blocks, wire ropes, hemp or manila ropes, winches, erection cleats and temporary braces or supports and all other materials required to deliver the Works complete in every respect.

All labour required for fabrication and erection for any cleaning, making good, rectifying, hauling, and painting and for any other ancillary work required to complete fabrication and erection.

The Contractor shall observe all safety requirements for erection of structural steelwork as covered in IS:7205.

7.2 Drawings:

- 7.2.1 The Engineer will supply to the Contractor profile drawings showing sizes of all structural members and typical connection details.
- 7.2.2 Should there be any discrepancy in the drawings the Contractor is to refer the matter to the Engineer. The Contractor shall further provide a drawing showing the accurate setting out to line and level of all the anchor bolts intended for the work in sufficient time for their inclusion in the work so as to maintain the building program.
- 7.2.3 The Contractor is to prepare all the necessary fabrication shop drawings and these shall be submitted to the Engineer in duplicate and be approved by him before fabrication is commenced. All such drawings shall show the dimensions of all parts, method of construction, welding and bolting. A further set of all approved fabrication drawings shall be supplied by the Contractor for use of the Engineer as required.
- 7.2.4 Approval by the Engineer of drawings or any other particulars submitted by the Contractor shall not relieve the Contractor of full responsibility for any discrepancies, errors or omissions therein. The Contractor shall at his own expense supply such additional copies of his working drawings as are required for the use of the interested parties.

7.3 Material:

7.3.1 Structural Steel

All structural steel shall be of tested quality and shall conform to one of the following standards:

- IS:226 Structural steel (Standard Quality)
- IS:2062 Structural steel (Fusion welding quality)
- IS:961 High Tensile Structural Steel (Ordinary)
- IS:1161 Steel Tubes for Structural purposes
- IS:4923 Hollow Steel Sections for Structural use
- IS 3757 & IS 4000 for high strength bolts in steel structures.
- IS 816 for use of metal arc welding for general construction in mild steel
- IS 9595 for Metal arc welding of carbon and carbon manganese steels
- IS 811 for Cold Formed Light Gauge Structural Steel Sections -

The Contractor shall supply to the Engineer copies of the manufacturer certificate that the steel brought to the site for incorporation in the works is of a quality fully complying with the specification.

If required by the Engineer, the Contractor shall arrange for testing of the steel samples as per IS:1608 - 1599.

7.3.2 Welding Electrodes:

Welding electrodes used for the works shall conform to IS:814/latest and shall be supplied by manufacturer approved by the Engineer and shall be of the grade approved by the Engineer. All Electrodes shall be kept under dry conditions. Any electrode which has part of its flux coating broken away or is damaged shall be rejected.

7.3.3 Bolts and Nuts:

Bolts and nuts used for the works shall unless otherwise specified be black bolts and nuts supplied by manufacturer approved by the Engineer and shall conform to IS 3757 & IS 4000

For the truss hot-dip galvanized (@ 300gm/sqm) bolt sleeve of mild steel grade 'B' conforming to IS:2062 and 4 dia 12mm anchor bars welded to same as per detailed drawing and instruction of the Engineer shall be provided. The length and diameter of sleeve shall be 300mm and 60mm respectively. The sleeve shall receive hexagon head bolt IS:1363 (part –I) –ISO 4016-M20x90-8.8. Hexagon head bolt shall be provided with galvanized spring washer as per the detailed drawing and instruction of the Engineer.

7.3.4 Washers

Plain washers shall be made of mild steel conforming to IS: 5369 (1975), unless otherwise specified. One washer shall be supplied with each bolt and, in case of special types of bolts, more than one washer as needed for the purpose shall be supplied. An additional double coil helical spring washer, conforming to IS:6755 (1980), shall be provided for bolts carrying dynamic or fluctuating loads and those in direct tension. Tapered washers, conforming to IS: 5372 (1975) and IS:5374 (1975), shall be used for channels and beams respectively wherever required.

7.3.5 For all other material required for the works, the approval of the Engineer shall be obtained by the Contractor prior to the use of the material in the works.

7.4 Workmanship and Fabrication:

7.4.1 For all the works, workmanship shall be of first class quality, throughout, in conformity with IS: 800-latest, and true to line, level and dimension as shown in the drawings or instructed by the Engineer.

7.4.2 All parts assembled for bolting shall be in close contact over the whole surface and all bearing stiffeners shall bear tightly at top and bottom without being drawn or caulked. The component parts shall be so assembled that they are neither twisted nor otherwise damaged as specified cambers if any shall be provided. Drilling done during assembling shall not distort the metal or enlarge holes. The butting surfaces at all joints shall be so cut and milled so as to butt in close contact throughout the finished joints.

7.4.3 Cutting shall be done automatically. Hand flame cutting will not be permitted.

7.4.4 The edges and ends of all cut/sheared flange plates, web plates of plate girders, and all cover plates, and the ends of all angles, tees, channels and other sections forming the flanges of plate girders, shall be planed/ground.

7.4.5 Holes for bolts shall be drilled to conform to clause 10 of ARE: 7215 (1974). Punching of holes will not be permitted. All drilling shall be free from burrs. No holes shall be made by gas cutting process.

7.4.6 All welding for the works shall be carried out by first class welders and shall be in accordance with IS:816, IS:819, IS:1024, IS:1261, IS:1323 and IS:9595. The Engineer may at his discretion order periodic tests of the welder and/or of the welds produced by them. All such tests shall be carried out by the Contractor at his cost.

7.4.7 Safety requirements should conform to IS: 7205, IS: 7273 and IS: 7269 as applicable and should conform to safety, economy and rapidity.

- 7.4.8 As much work as possible shall be welded in shops. The pieces shall be manipulated to ensure down hand welding for all shop joints as far as possible. All parts to be welded shall be arranged so as to fit properly on assembly. After assembly and before the general welding is to commence the parts are to be tack welded with small fillet or butt welds as the case may be. The tack welding must be strong enough to hold the parts together but small enough to be covered by the general welding. The welding procedure shall be so arranged that the distortion and shrinkage stresses are reduce to a minimum.
- 7.4.9 All joints required in structure to facilitate transport or erection shall be shown on the drawings or as specified by the Engineer. Should the Contractor need to provide joints in locations other than those specified by the Engineer he shall submit his proposals and obtain the prior sanction of the Engineer for such joints. The lengths of structural shall be the maximum normally available in the market jointing of shorter length in order to make up lengths required shall not be permitted.
- 7.4.10 Each piece of steel work shall be marked distinctly before delivery, indicating the position and direction in which it is to be fixed. Three copies of a complete marking plan are to be supplied to the Engineer before erection commences.
- 7.4.11 In the case of welded fabrication any distortion remaining in the member after welding operations are completed shall be rectified by and/or at the expense of the Contractor to the approval of the Engineer.
- 7.4.12 All members of trusses and lattice girders shall be straight throughout their length, unless shown otherwise on the drawings, and shall be accurately set to the lines shown on the drawings. Sheared edges of gussets or other members to be straightened and dressed where necessary.
- 7.4.13 Templates and jigs used throughout the work shall be all steel. In cases where actual materials have been used as templates for drilling similar pieces, the Engineer shall decide whether they are fit to be used as parts of the finished structure.
- 7.4.14 Apart from the requirements of welding specified under the above sub clauses, sections above, the Contractor shall ensure the following requirements in the welded joints.
- i) Strength-quality with parent metal.
 - ii) Absence of defects
 - iii) Corrosion resistance of the weld shall not be less than that of parent material in an aggressive environment.
- 7.4.15 No gasket or other flexible material shall be placed between the holes. The holes in parts to be joined shall be sufficiently well aligned to permit bolts to be freely placed in position. Driving of bolts is not permitted. The nuts shall be placed so that the identification marks are clearly visible after tightening. Nuts and bolts shall always be tightened in a staggered pattern and, where there are more than four bolts in any one joint, they shall be tightened from the centre of the joint outwards.

7.5 Testing of Welds:

- 1 Butt welds - Radiographic testing of 5% of welds as per IS 1182.
- 2 Fillet welds - Ultrasonic testing of 5% of welds.
- 3 All welded connections shall be inspected as per IS:822
- 4 All welds shall be tested by "dye penetration test" as per current practices.
- 5 Agency for testing of weld shall be approved by the Engineer prior to testing.
- 6 Defected welds shall be repaired or replaced as decided by the Engineer. The repaired or replaced welds shall be tested using the same methods as above. Additionally, when defective welds are found, the cause of the defective welding shall be determined and the contractor shall institute immediate corrective action.
- 7 No extra payment shall be made for the tests indicated above.

7.6 Protection of Steel Works (IS:8629):

- a) Sand blasting where specified shall be carried out in accordance with IS:1477.
- b) Painting work shall be carried out in accordance with IS:8629 (Parts I to III). Painting shall be applied under the temperature requirement specified by the manufacturer.
- c) The steel work, prior to delivery, shall be cleaned form scale, rust, dirt and grease etc., but means of chipping, scraping and wire brushing using skilled operators as described in the painting systems below. The cleaning shall proceed each day over the extent of surfaces

- which can be painted on that day. The paint shall be applied by brushing or spraying as per approval of the Engineer.
- d) Paint brushes round/oval and flat shall be conforming to IS:487 and IS:384 codes respectively, if painting with brushing is approved by Engineer.
 - e) The spraying equipment shall be compatible with the paint material, fitted with necessary gauges and controls and approved by the Engineer.
 - f) Site weld locations shall be left free from paint within 50mm of the weld position, and contact surfaces in connection using High Strength Friction Grip Bolts shall not be painted. Immediately after completion of erection all damaged paint shall be scraped off and made good to the approval of the Engineer.
 - g) The Steelwork specialist shall also clean down and apply one coat of primer to all site bolts, site bolted connections and site weld locations and the paint work generally shall be left in sound condition for any subsequent painting.
 - h) All paints and primers shall be of best quality and in original sealed containers as packed by the paint manufacturer conforming to the relevant Indian Standards and shall be procured directly from the manufacturers. All paint to be used shall be stored under cover in such conditions as will preserve it from extreme of temperature and the paint shall be used and applied strictly in accordance with the manufacturer's instructions.
 - i) In addition, the following specification shall apply to the shop painting of contact and inaccessible surfaces:
 - a. Surfaces to be painted shall be thoroughly cleaned from scale, rust, dirt, grease etc. by means of sand/grit/shot blasting or other equivalent means.
 - b. Surfaces which are to be brought permanently into close contact or made inaccessible either in the shops or upon erection shall, after cleaning, be given two coats of Red Lead Priming Paint. The surfaces shall be brought into contact while the paint is still wet.
 - c. Contract surfaces in connection using High Strength Friction Grip bolts shall not be painted or oiled and shall be free from dirt, loosed scale, burrs, pits and any other defects which would prevent the solid seating of the parts and would interfere with the development of friction between them.
 - d. All enclosed surfaces of box members shall be completely sealed by oiling or by coating with approved bitumen paint and all such members and tubes shall have their ends closed by suitable plates welded in position.
 - j) Surfaces in contact during shop assembly shall not be painted. Surfaces which cannot be painted, but require protection, shall be given a rust inhibitive grease conforming to IS: 958 (1975), or solvent deposited compound conforming to IS:1153 (1975) or IS:1674 (1960), or treated as specified in the drawings.
 - k) Surfaces to be in contact with concrete shall not be painted.

7.7 Erection & Site Work:

- 7.7.1 The Contractor shall be responsible for checking the alignment and level of foundation and correctness of foundation bolt centres, well in advance of starting erection work, and shall be responsible for any consequences for non-compliance thereof. Discrepancies if any shall immediately be brought to the notice of the Engineer for his advice.
- 7.7.2 The structure should be divided into erectable modules as per the total scheme. This should be pre-assembled in a suitable yard/platform and its matching with members of the adjacent module checked by trial assembly before erection.
- 7.7.3 Immediately prior to erection any rust in the paint area shall be removed by power wire brushing to a standard equivalent to SA3.
- 7.7.4 During erection the rough handling of fabricated materials such as bending, straining or pounding with sledges shall be avoided. Any damage to the structure during transportation or erection shall be immediately rectified by the Contractor at his own cost. The straightening of bend edges of plates, angles and other sections shall be done by methods which will not cause fracture.
- 7.7.5 Following the completion of the straightening, the surface of the member shall carefully be inspected for damage and got approved by the Engineer before further use.

- 7.7.6 The Contractor shall be responsible for accurately positioning, leveling and plumbing of all steelwork and placing of every part of the structure in accordance with the approved drawings and to the satisfaction of the Engineer. All stanchion base, beam and girder bearings etc. shall be securely supported on suitable steel packs. All reference and datum points shall be fixed near the work site for facilitating the erection work.
- 7.7.7 All equipment used by the Contractor shall be sufficient for the purpose and for the erection of the steel work, in the time specified in the contract. Any lifting or erecting machinery shall be to the approval of the Engineer and shall be removed from the site if he considers such appliances dangerous or unsuitable for their functions. The approval of the Engineer shall not relieve the Contractor of the responsibilities for the loads to which the erection equipment shall be called upon to carry. Adequate arrangement shall be made to resist wind loads and lateral forces arising at the time of erection.
- 7.7.8 The Contractor is entirely responsible for the stability of the structure during erection and shall arrange that sufficient tack bolts, braces or guy ropes are used to ensure that work will remain rigid until final bolting, riveting or welding is completed. The Contractor shall supply and fix, without extra charge, any temporary bracing which may be necessary.
- 7.7.9 All steelwork shall be erected in the exact position as shown on the drawings. All vertical members shall be truly vertical throughout and all horizontal members truly horizontal, fabrication being such that all parts can be accurately assembled and erected. No permanent bolting, welding or grouting shall be done until proper alignment has been obtained and checked by the Engineer.
- 7.7.10 At stanchion splices and at other positions where concrete cover to the steel is liable to be restricted, bolts will be placed with their heads on the outside of the members.
- 7.7.11 All field assembly bolting and welding shall be executed in accordance with the requirements for shop fabrication excepting such as manifestly apply to shop conditions only. Where steel has been delivered painted the paint shall be removed before field welding for a distance of at least 50mm on either side of the joints. The number of washers on permanent bolts shall not be more than two for the nut and one for the bolt head.

7.8 Rectification of damaged materials :

Any error in shop work which prevents the proper assembly and lifting up of the parts by moderate use of drift pins or reaming or cutting shall be immediately reported to the Engineer and his approval of the method of rectification obtained in writing. Wrongly fabricated material whose erection in the field necessitates extra work shall be the responsibility of the contractor. The entire costs of such operation including the replacement of defective members, if required, shall be borne by the contractor.

7.9 Inspection :

- 7.9.1 The contractor shall inform the Engineer of the progress in fabrication and as to when individual pieces are ready for inspection. All gauge templates necessary to satisfy the Engineer shall be supplied by the contractor. The Engineer may at his discretion check the results obtained at the contractor's works by independent tests and should the material so tested be found unsatisfactory, the cost of such tests shall be borne by the contractor.
- 7.9.2 Structural steel and components viz. bolts, nuts, washers, welding consumables, etc. should be tested for mechanical and chemical properties as per the requirement of the relevant IS or any other specified codes/standard.
- 7.9.3 During Inspection, the component/member shall not have any load or external restraint.

7.10 Grouting of steel bases :

- 7.10.1 Before grouting of stanchion bases, the contractor shall take the following action:
- a. Inform the Engineer.

- b. Clean all holes, openings, recesses and the top of foundations of all dirt, mud, water, oil or other extraneous matter.
- c. A frame shall be placed in position around the base plate with a provision for placing or injecting grout.
- d. The contractor shall provide screed bars or mild steel flats and fix them in mortar.
- e. Holes shall be provided on the stanchion bases for escape of air.

7.10.2 Grouting of steel beams, steel stanchions, bases and bearings and encasement of steelwork will be carried out by the contractor after the steelwork has been finally aligned and leveled and approval of the Engineer obtained.

7.10.3 The bolt sleeves shall be grouted as a separate operation using neat cement grout of a creamy consistency, which shall be poured in so as to completely fill the holes. "Non-shrink" cements, additives of approved makes shall be used for all grouting operations.

7.10.4 The space between the top of the foundations and the underside of the base plate shall be completely filled with a mix 1:2 cement sand mortar and finished flush with edge of the base plate, either:

- a. Mixed as a stiff mortar well rammed into place from all sides.
- b. Mixed as thickly as possible consistent with fluidity and poured under a suitable head and tamped until the space has been properly filled.

7.11 Holding down and Anchor bolts:

7.11.1 The holding down and anchor bolts should conform to the requirements laid down in IS:5624 or as directed by the Engineer.

7.11.2 Installation: Individual bolts in groups of holding down bolts shall be positioned accurately within a tolerance of +6mm. The bolts shall be set vertically to a tolerance of not more than 1 in 250.

7.11.3 During the casting of concrete the contractor shall ensure that space between the bolt and sleeves is kept clean after removal of shuttering. The contractor shall provide and fix timber plugs to maintain this space in a clean condition. The projecting threads of bolts shall be protected by approved wrapping materials.

7.11.4 Grouting of bolt tubes shall be carried out after the steelwork or equipment have been aligned, plumbed and levelled.

7.12 Tolerances:

7.12.1 All tolerances shall be in accordance with IS: 7215 unless otherwise specified.

7.12.2 The maximum deviation for line and level shall be + 3.0mm for any part of the structure including for location of column centres.

7.12.3 The maximum deviation from plumb for columns shall be +3.0mm in 10.0m height subject to a maximum of +6.0mm in a total height of 30.0m.

7.12.4 The deviation at the centre of the upper chord member from vertical plane running through the centre of the bottom chord shall not be more than 1/1500 of span but in no case more than 10.0mm. The lateral displacement of top chord at centre of span from vertical plane running through centre of supports shall not be more than 1/250 of the depth of truss but in no case more than 20.0mm.

7.13 Mode of measurement :

7.13.1 The pricing must include for all rolling margins, extras for length and size, allowance for waste, complete fabrication, delivery and erection, and caulking the gap between base plate and foundation, and painting as specified in the item.

7.13.2 Any temporary strutting, tying or anchor bolts, black bolts, fasteners, welding required to withstand the

stresses of erection and carrying of plant are to be included in the price.

- 7.13.3 The payment for the steelwork will be for the weight of the steelwork actually erected, i.e. plates, rolled sections, shear connections, cleats, splice plates.
- 7.13.4 Dimensions of the steelwork will be taken correct to 1 mm and the net weight of metal in the fabricated structure on the basis of unit weight of the steel used in the works approved by the Engineer worked out on site or from the actual shop working drawings as decided by the Engineer. In calculating the weights of gusset plates, payment will be made for the least enclosing parallelogram or triangle. For structural sections the weight will be calculated on lengths actually used with no deduction for splay cut or mitred end. In case of imported sections, the weights chargeable shall be the weight according to the relative standards of the country of origin. Full weight of the bolts and nuts will be paid for as per Indian Standard Codes weights without any deduction for shanks, etc. No account shall be taken of the weight of weld in calculating the weight of steelwork. Erection packing plates bedded in mortar and wedges shall not be measured but shall be included in the rates. No deduction shall be made for openings less than 0.1m² in area measured in plane for bolt holes. The weight of sheet steel, plate, strips and rolled sections shall be taken from relevant Indian Standards.
- 7.13.5 The structural work which is temporary in nature and/or which is required for erection purposes shall not be measured.

(B) Structural Steel Specifications -Painting Works

7.14.1 General

Scope of Specification

This Specification covers the scope of painting, methods for the surface preparation, application of paints and precautions to be taken for the painting of structural steel work. It covers the supply and delivery of all necessary materials, labour, scaffolding, tools, equipment and everything that is necessary for the job completion on schedule.

Applicable Codes

The following Specifications, Standards and Codes are included as part of this Specification. All standards and codes of practice referred to herein shall be the current editions during the currency of project including all applicable official amendments and revisions.

In case of discrepancy between this Specification and those referred to herein, this specification shall govern. In case of discrepancy between Contract drawings and this specification, the Contract drawings shall govern.

- | | | |
|-----|----------------|---|
| a). | IS: 102 (1962) | : Ready Mixed Paint, Brushing, Red lead, Non Setting, Priming. |
| b). | IS: 159 (1981) | : Ready Mixed Paint, Brushing, Acid Resisting for Protection against Acid Fumes, Colour as Required. |
| c). | IS: 384 (1979) | : Brushes, Paints and Varnishes, Flat. |
| d). | IS: 487 (1985) | : Brush, Paint and Varnish i) Oval Ferrule Bound
ii) Round Ferrule Bound. |
| e). | IS: 958 (1975) | : Temporary Corrosion Preventive Grease, Soft Film, Cold Application. |
| f). | IS: 1153(1975) | : Temporary Corrosion Preventive, Fluid, Hard Film, Solvent Deposited |
| g). | IS: 1477(1971) | : Code of Practice for Painting of Ferrous Metals in Building.
Part I –Pretreatment
Part II –Painting |
| h). | IS: 1674(1960) | : Temporary Corrosion Preventive Fluid, Soft Film, Solvent Deposited. |
| i). | IS: 2074(1992) | : Ready Mixed Paints, Red Oxide -Zinc Chromate. |
| j). | IS-5666 | : Etch (Pretreatment) Primer |
| k). | IS-104 | : Ready mixed paint, brushing, zinc chrome, priming |

- I). IS-2339 : ALUMINIUM PAINTS FOR GENERAL PURPOSES " SPECIFICATION

7.14.2 Products & Materials

Paint

1. All paint delivered to the fabrication shop shall be ready mixed, in original sealed containers, as packed by the paint manufacturers, and no thinners shall be permitted.
2. Paint shall be stirred frequently to keep the pigment in suspension

Storage of Paints

1. All paints shall be stored strictly in accordance with the requirements laid down by the paint manufacturers. The storage area shall be well ventilated and protected from sparks, flame, direct exposure to sun or excessive heat, preferably located in an isolated room or in a separate building.
2. All paint containers shall be clearly labelled to show paint identification, date of manufacture, batch number, order number and special instructions in legible form. The containers shall be opened only at the time of use. Paints which have liveried, gelled or otherwise deteriorated during storage shall not be used. Paints for which the shelf life specified by the supplier has expired shall not be used without inspection and approval by the Engineer-in-charge.

Execution

Paint System (High Performance Polysiloxane System)

Sand blasting shall be carried out in accordance with IS: 1477.

Painting work shall be carried out as follows:

Description	Surface	
Fabrication Shop	External Surfaces	Internal Surfaces
Surface Treatment	Abrasive Blast to SA 2.5(ISO 8501-1:1988). If oxidation occurs between blasting and application of paint, the surface shall be re blasted to the specified standard.	Abrasive Blast to cleaning to minimum SA 2.5 (Swedish Standard SIS 055900), Near-White blast cleaning.
primer	Providing & applying two component high build Zinc Rich Epoxy Primer Poly amide cured with minimum volume Solids of approximately 60% and a product weight of 2.50 kg/liter, minimum recoat interval of not more three hours at 25 deg C. The primer can be like Interzinc 52 of International Paints or approved equivalents. DFT-75 microns The primer shall be applied by Conventional/Airless Spray only in Shop.	Surface Tolerant Epoxy with minimum Volume Solids of 80%, minimum overcoat interval of not more than 24 hours at 25 deg C and a product weight of 1.6kg/liter. The primer can be like Interseal 670 HS of international paints or approved equivalent DFT-150 microns
1st Coat	Providing and applying two component Hi Build Epoxy intermediate Coat pigmented with Micaceous Iron oxide with approximate Volume Solids of 80%, minimum re-coat interval of 6 hours at 25 deg C and a product weight of approximately 2 kg/liter- like Intergard 475 HS of international paint or approved equivalent. DFT-150 microns The coat shall be applied by Conventional/Airless Spray only in Shop	
Erection Site		
Touch up Primer	Power Tool Cleaning to ST 2 standards followed by Surface Tolerant Epoxy with minimum Volume	

	<p>Solids of 80%, minimum overcoat interval of not more than 24 hours at 25 deg C and a product weight of approximately 1.6kg/liter like Interseal 670 HS of International Paints or approved equivalent. This primer shall be applied as touch up wherever damages have occurred on account of welding or Transportation & Erection.(Stripe Coat)-The DFT shall not be included in the Total DFT of System</p> <p>DFT-75 microns</p> <p>The primer shall be applied by Conventional/Airless Spray only at site</p>	
2 nd coat(Finish Paint)	<p>Providing and applying two components Hi Gloss Acrylic Polysiloxane Finish Paint with approximate Volume solids of 70%, The product shall hard dry in not more than 5 hours at 25 deg C and 50% R.H. like Interfine 878 of International Paints or approved equivalent. This product should exhibit Gloss Retention following 3000 hours to U.V-A fluorescent lamp when checked as per ASTM-523</p> <p>DFT-75 microns</p> <p>The paint shall be applied by Conventional/Airless Spray only at site.</p>	

The total Average DFT of External Surface is 375 microns

The total Average DFT of Internal Surface is 150 microns

DFT measurements should be done in accordance with Specifications SSPC PA 2.

INTERNAL SURFACE = Internal surface are those which will become inaccessible after fabrication and are not prone to humidity and moisture from the atmosphere.

EXTERNAL SURFACE = All other surfaces which are prone to humidity and moisture from the atmosphere.

The following precautions must be taken:

- a). After abrasive blast cleaning, the first undercoat (primer coat) should be applied well before surface deterioration.
 - b). Over coating intervals, application parameters shall conform to manufacturer's instruction manual.
 - c). The DFT (Dry film thickness) shall be measured after completion of each coat.
- Surface Preparation (sandblasting)

All surfaces shall be cleaned of loose substances and foreign materials. e.g. dirt, rust, scale, oil, grease, welding flux etc so that the primer coat adheres to the original metal surface. The work shall be carried out in accordance with IS: 1477 (1971) (Part I). Any oil, grease, dust or foreign matter deposited on the surface after preparation shall be removed and care shall be taken to ensure that the surface is not contaminated with acids, alkalis or other corrosive chemicals. The primer coat shall be applied immediately after the surface preparation is completed.

Before the application of any paint the surfaces to be treated shall be thoroughly cleaned freed from all scale, loose paint, rust and other deleterious matters. Oil and grease shall be removed from the surface by washing with solvents or with a detergent solution before blast cleaning operation of metal polish with metal pellets. If any traces of oil or grease remain after blasting they shall be removed by solvent cleaning and the area will be re-blasted thereafter.

All welding areas shall be given special attention for removal of weld flux slag, weld metal splatter weld head oxides; weld flux fumes silvers and other foreign objects before blasting. If deemed necessary by the Engineer in Charge, acid washing and subsequent washing with clean water shall be used.

Any rough seams will have to be ground and must be inspected and approved by the Engineer-in-charge before application of the coatings.

All structural steel to be painted shall be cleaned using blast cleaning in accordance with SA 2 1/2 Near- White Blast cleaning (equivalent Swedish Standard SIS 055900). For SA 2 1/2 the profile should be in the range of 40-70 microns and shall be measured with comparator. Mill scale, rust and foreign matter shall be removed to the extent that the only traces remaining are light stains in the form of spots or stripes. Finally the surface shall be cleaned with a vacuum cleaner or clean dry compressed air.

The blast cleaning shall produce a surface roughness complying with the one specified by the paint manufacturer for the primer concerned. If, cleaned surfaces are rusted or are contaminated with foreign material before painting is accomplished they shall be re-cleaned by the Contractor at his own expenses. Nothing extra shall be paid on this account.

- **Mixing of paint**

All ingredients in a paint container shall be thoroughly mixed to break-up lumps and disperse pigments, before use and during application, to maintain homogeneity. All pigmented paints shall be strained after mixing to remove skins and other undesirable matters.

1. Dry pigments, pastes, tinting pastes and colours shall be mixed and/or made into paint so that all dry powders get wetted by vehicles and lumps and particles are uniformly dispersed.
2. Additives that are received separate such as curing agents, catalysts, hardeners etc. shall be added to the paint as per the manufacturers' instructions. These shall be promptly used within the pot life specified by the manufacturers and unused paint thereafter shall be discarded.
3. Thinners shall not be used unless essential for proper application of the paint. Where thinners are used, they shall be added during the mixing process and the type and quantity of thinner shall be in accordance with the instructions of paint manufacturer.

- **Paint Application**

General

- Paint shall be applied in accordance with the manufacturer recommendations, as supplemented by these Specifications. The work shall generally follow IS 1477 (1971) Part II. Prior approval of the Engineer-in-charge shall be taken in respect of all primers and/or paints, before their use in the works.
- Paint shall generally be applied by brushing except that spraying may be used for finish coats only when brushing may damage the prime coats. Roller coat or other method of paint application shall not be used unless specifically authorized.
- Paint shall not be applied when the ambient temperature is 10°C and below. For paints, which dry by chemical reaction the temperature, requirements specified by the manufacturer shall be met with. Also, paint shall not be applied in rain, wind, fog or at relative humidity of 80% and above or when the surface temperature is below dew point, resulting in condensation of moisture. Any wet paint exposed to damaging weather conditions shall be inspected after drying and the damaged area repainted after removal of the paint.
- Each coat of paint shall be continuous, free of pores and of even film thickness without thin spots. The film thickness shall not be so great as to detrimentally affect either the appearance or the service life of the paint.
- Each coat of paint shall be allowed to dry sufficiently before application of the next coat, to avoid damages such as lifting or loss of adhesion. Undercoats having glossy surface shall be roughened by mild sand papering to improve adhesion of subsequent coats. Successive coats of same color shall be tinted. Whenever practical, to produce contrasts and helps in identifying the progress of the work.

Brush Application

- Proper brushes shall be selected for a specific work piece. Round or oval brushes which conform to IS: 487(1985) are better suited for irregular surfaces, whereas flat brushes which

conform to IS: 384(1979) are convenient for large flat areas. The width of flat brushes shall not generally exceed 1.25mm.

- Paint shall be applied in short strokes depositing a uniform amount of paint in each stroke followed by brushing the paint into all surface irregularities, crevices and corners and finally smoothening or leveling the paint film with long and light strokes at about right angles to the first short strokes. All runs and sags shall be brushed out. The brush marks left in the applied paint shall be as few as practicable.

Spray Application

1. The spraying equipment shall be compatible with the paint material and provided with necessary gauges and controls. The equipment shall be cleaned of dirt, dried paint, foreign matter and solvent before use.
2. The paint shall be applied by holding the gun perpendicular to the surface at a suitable distance and moved in a pattern so as to ensure deposition of a uniform wet layer of paint. All runs and sags shall be brushed out immediately. Areas not accessible to spray shall be painted by brush or dauber.
3. Water trap acceptable to Engineer-in-charge shall be furnished and installed on all equipment used in spray painting.

Shop Painting

1. The painting system specified in Table shall be followed. Surfaces, which will be inaccessible after field assembly, shall receive the full-specified protective treatment before assembly.
2. Surfaces in contact during shop assembly shall not be painted. Surfaces which cannot be painted but require protection shall be given a rust inhibitive grease conforming to IS:958-1975 or solvent deposited compound conforming to IS: 1153 (1975) or IS: 1674 (1960) or treated as specified in the drawing.
3. The shop coats shall be continuous over all edges, including ends meant for jointing at site by bolting, except where the paint could be detrimental to bolting. In such cases, no paint shall be applied within 50mm, and the unprotected surface shall be given a coat of corrosion inhibitive compound.
4. The unpainted area shall be cleaned prior to welding. The welded joint shall be cleaned and deslagged, and immediately after covered by the same paint as has been used for the remaining surface.

Painting at Site

Surfaces which will be inaccessible after site assembly shall receive the full specified protective treatment before assembly. Surfaces which will be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet.

Damaged or deteriorated paint surfaces shall be first made good with the same type of coat as the shop coat. Where steel has received a metal coating in the shop, this coating shall be completed on site so as to be continuous over any welds, bolts and site rivets. Specified protective treatment shall be completed after erection.

Protection of Paint work

The Contractor shall provide measures as necessary to prevent damage to the work and to other property or persons from all cleaning and painting operations. Paint or paint stains, which result in other unsightly appearance on surfaces not designated to be painted, shall be removed or obliterated by the contractor at his cost.

All painted surfaces that in the opinion of the Engineer-in-charge are damaged in anyway, shall be repaired by the contractor at his cost with materials and to a condition equal to that of the requirements specified in these specifications.

Upon painted surfaces that in the opinion of any other work that would cause dust, grease or foreign materials to be deposited upon the painted surfaces, the painted surfaces shall be thoroughly cleaned.

The areas for high-strength bolts shall be protected by masking tape against undercoat application at the fabrication shop. Immediately prior to erection any rust in the paint area shall be removed by power wire brushing to a standard equivalent to SA3.

7.14.3 STRUCTURAL STEEL WORK-ERECTION

7.14.3.1 General

7.14.3.1.1 Scope of Specifications

This Specification covers the delivery to site, storage and erection of structural steelwork at site. This includes plant and equipment requirements, installation of fabricated steel work in position and grouting all complete as per drawings, specifications and other provisions of the Contract.

7.14.3.1.2 Submittals

- A. Ref. Specification for Structural Steelwork Erection –General
- B. The contractor shall submit for approval a full description of his proposed erection method including sequence of erection, use of temporary supports, connection details and erection camber diagram and design calculations covering various stages of erection process.

7.14.3.2 Execution

7.14.3.2.1 Delivery, Storage & Handling

- A. Before the shop assembly is dismantled, all members and sections shall be appropriately marked with paint or grooved with their identification numbers as detailed in shop drawings. The Contractor's representative shall be present during all the shop assemblies (wherever fabrication will be done) , its dismantling and marking operations.
- B. The Contractor shall deliver the fabricated structural steel materials to site, with all necessary field connection materials, in such sequence as will permit the MoRT&H efficient and economical performance of the erection work. As per scheduled programme, the Engineer may, at his discretion prescribe or control the sequence of delivery of materials.
- C. Fabricated parts shall be handled and stacked in such a way-that no damage is caused to the components. Measures shall be taken to minimize damage to the protective treatment on the steelwork. All work shall be protected from damage in transit. Particular care shall be taken to stiffen free ends, prevent permanent distortion and adequately protect all machined surfaces. All bolts, nuts, washers, screws, small plates and articles shall be suitably packed and identified.

7.14.3.2.2 Plant and Equipment

All erection tools and plant & equipment proposed to be used shall be efficient, dependable duly certified by independent third party and in good working condition, and the suitability and adequacy of such shall be determined by the Engineer. The Contractor shall, in his technical proposal submittal, specify the plant and equipment proposed by him for erection of structural steelwork at Site.

7.14.3.2.3 Storage

Materials to be stored shall be placed on skids above the ground and shall be kept clean and properly drained.

7.14.3.2.4 Method and Sequence of Erection

The method and sequence of erection shall have the prior approval of the Engineer. The contractor shall arrange for the MoRT&H economic method and sequence consistent with the drawings and Specifications and such information as may be furnished to him prior to the execution of the Contract. The erection of steelwork shall be planned so as to ensure safe-working conditions at all times. The Contractor shall be solely responsible for enhancing the safety of his construction activities at Site.

7.14.3.2.5 Assembly & Erection

- A. During erection, the members and sections shall be accurately assembled as shown in the approved shop drawings and by following the match marks. The material shall be carefully handled so that no section will be bent, broken or otherwise damaged. Hammering which will damage or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Splices and field connections shall have 50% of the holes filled with bolts and balance 50% with cylindrical erection pins before bolting with high-strength bolts. Filling-up bolts shall be of the same nominal diameter as the high-strength bolts, whereas the cylindrical erection pins shall be 1 mm or larger in diameter.
- B. The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting, shall be reported immediately to the Engineer and his approval of the method of correction obtained. The contractor shall be responsible for all misfits, errors and injuries and shall make the necessary corrections and replacements.
- C. The straightening of plates, angles, other shapes and built-up members, when permitted by the Engineer, shall be done by methods that will not produce fracture or other damages. Distorted members shall be straightened by mechanical means or, if approved by the Engineer, by the carefully planned and well supervised application of a limited amount of localized heat. Each application will be subject to the approval of the Engineer.
- D. The responsibility in respect of temporary bracing and guys shall rest with the Contractor until the structural steel is located, kept in plumb, leveled, aligned and grouted within the tolerances permitted under the Specifications, and the permanent bracing/framing system has been installed.
- E. The temporary guys, braces, false work and cribbing shall not be the property of the Engineer/Employer and will be removed by the Contractor, with the approval of the Engineer, without any charge, once the permanent framing system has been installed to the satisfaction of the Engineer and when the temporary bracing, guys etc. can be removed without any potential danger/damage to the erected structure.

7.14.3.2.6 Setting Out

- A. Positioning and leveling of all steelwork, keeping in plumb and placing of every part of the structure, with accuracy, shall be in accordance with the approved drawings and to the satisfaction of the Engineer. The Contractor shall check the positions and levels of the anchor bolts etc. before concreting and ensure that they are properly secured against disturbance during pouring operations. The Contractor shall remain responsible for correct positioning and shall set proper screed bars to maintain proper level. No extra payment shall be made on this account.
- B. No permanent field connections by bolting shall be carried out until proper alignment and guides for keeping in plumb have been attached.

7.14.3.2.7 Field Bolting

- A. Bolts shall be inserted in such a way that they remain in position under gravity, even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled all joint surfaces including those adjacent to the washers shall be free of scales. They shall be free of dirt, loose scales, burns and other defects that would prevent solid seating of the parts.
- B. Holes for turned bolts to be inserted in the field shall be reamed in the field. All drilling and reaming for turned bolts shall be done only after the parts to be connected are assembled. Tolerances applicable in the fit of the bolts shall be in accordance with relevant Indian Standard Specifications.
- C. All high tensile bolts shall be tightened to provide the required minimum bolt tension as per relevant Indian Standards / Specifications when all fasteners in the joint are tight,
- D. The manufacture and use of high strength friction grip bolts shall comply with the requirements of IS:3757 (1985).
- E. Load indicating bolts or washers may be used, subject to the approval of the Engineer.

7.14.3.2.8 Holes, Cutting and Fitting

- A. No cutting of sections, flanges, webs, and cleats, rivets, bolts, welds etc. shall be done unless specifically approved and / or instructed by the Engineer.
- B. The erector shall not cut, drill or otherwise alter the work of other trades, or his own work to accommodate other trades, unless such work is clearly specified in the Contract, or directed by the Engineer. Wherever such work is specified, the Contractor shall obtain complete information as to size, location and number of alterations, prior to carrying out any work.

7.14.3.2.9 Drifting

- A. Correction of minor misfits will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to enlarge holes, as necessary, to make connections. Reaming, that weakens the member or makes it impossible to fill the holes properly or to adjust accurately after reaming, shall not be allowed.
- B. Any error in shop work which prevents the proper assembling and fitting of parts by moderate use of drift pins and reamers shall immediately be brought to the attention of the Engineer, and approval of the method of correction obtained. The use of gas cutting torches at the erection site is prohibited.

7.14.3.2.10 Grouting

- A. The positions to be grouted shall be cleaned thoroughly with compressed air jet and wetted with water, and any accumulated water shall be removed. Grouting shall be carried out under expert supervision, taking care to avoid air locks. Edges shall be finished properly.
- B. Whatever method of grouting is employed, the operation shall not be carried out until the steelwork has been finally aligned and leveled. Immediately before grouting, the space under steel is thoroughly cleaned. Where packings are to be left in place, they shall be placed such that they are completely covered with grout.
- C. The grout to be used shall be Non-shrink grout conbextra GP-2 of M/S Fosroc or equivalent.

- D. All steel in foundations shall be solidly encased in Portland Cement Concrete of minimum characteristic strength at 28 days as specified in the drawings, subject to a minimum of 35 N/mm². A minimum cover of 100mm shall be provided to all steelwork where surrounding concrete is in contact with soil.

7.14.3.2.11 Inserts and Embedment

Various steel inserts and embedment are required under the contract to be fabricated, positioned and secured firmly into place inside the formwork prior to concrete being poured. There are also requirements of jointing, threading, bolting and welding inserts and embedment of different concrete and structural steel elements in order to establish structural continuity and connection. Great care shall be exercised by the contractor in executing all aspects of the work related to inserts and embedment, including tolerances, so that the final assembly of the concrete elements can meet satisfactorily the continuity and contiguity requirements intended in the structure.

7.14.3.2.12 Painting after Erection

- A. The surfaces required to remain unpainted at shop, shall be given a protective coating after the structure is erected, leveled, kept in plumb, aligned in its final position, and accepted by the Engineer. However, touch up painting, making good any damaged shop painting and completion of any unfinished portion of the shop coat shall be progressively carried out by the Contractor.
- B. Painting shall not be done in frost or foggy weather, or when humidity is such as to cause condensation on the surfaces to be painted. Before, commencing painting of steel, which is delivered unpainted, all surfaces to be painted shall be dried and thoroughly cleaned from all loose scale and rust.
- C. Surfaces, which will be inaccessible after field assembly, shall receive the full-specified protective treatment before assembly. Bolts and fabricated steel members, which are galvanised or otherwise treated, shall not be painted.
- D. The contractor shall be responsible for any damage caused to other components of the structure including the substructure. In particular, he shall take all necessary precautions to minimise concrete splash onto completed steelwork or rust staining of concrete due to erected steel work and clean and/or repair all stains and other damages to completed work prior to tests on completion.

7.14.3.2.13 Final Cleaning up

Upon completion of erection, and before final acceptance of the work by the Engineer, the Contractor shall remove, free of cost, all falsework, rubbish and all temporary works, resulting from or in connection with the performance of his work.

7.14.4 ADDITIONAL SPECIFICATIONS FOR LAUNCHING

Truss launching for longer spans:

- Preferably no road traffic blocking will be used. Multiple day/night short blocks of 1h to 1h30 maximum are acceptable to ensure safety.
- Launching scheme shown in Tender drawings is suggestive only. Contractor has to provide his own proposed launching scheme and supporting calculations with the offer.
- Contractor has to provide principles of nose/truss connection details in tender.
- The contractor has to obtain approval from the Southwestern Railway for the railway span of BP503 and BP 504.
- Truss design composite girder requirements will govern over nose/launching equipment requirements.
- Contractor will submit and get approval from Engineer of the detailed design of the full launching equipment and scheme before starting the launching.
- Contractor will coordinate with Bangalore Traffic Police and Engineer before and during the launching contractor to develop detailed traffic diversion scheme.

- Tentative allowable bearing pressure for temporary supports foundation concrete blocks shall be assumed at 10 tonnes/sqm.
- Any necessary precaution by proper and secure fixing shall be taken by the contractor to prevent the fall of any object onto the road below during the whole erection period.
- A minimum 15m clear width (4 lanes) shall be kept during the whole construction period. These lanes can be obtained as 4 or 2+2.

7.14.5**MODE OF MEASUREMENT**

- 1 The unit rate shall include the following:
 - i. Erection of fabricated parts (fabrication and transportation of various parts / components including HSFG bolts/nuts / washers from workshop to storage yard will be done by approved sub-contractors)
 - ii. Receiving, unloading and keeping in safe custody and upkeep of all fabricated parts including HSFG bolts/nuts / washers at storage yard.
 - iii. Loading, transportation and unloading of all fabricated structural steel materials including HSFG bolts/nuts / washers from site storage yard to erection site, handling, assembling, bolting, welding if necessary and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and/or as directed by the Engineer.
 - iv. Tightening of HSFG bolts for the field erection of fabricated parts. However, supply of HSFG bolts and its compatible nuts and washers will be arranged / supplied at the storage yard by approved sub-contractor.
 - v. Preparation of complete detailed erection drawings and detailed calculation based on suggested erection sequence and design drawings as given by Engineer or alternative scheme proposed by contractor and approved by Engineer.
 - vi. Preparation of complete detailed fabrication drawings for all temporary structures such as temporary nose, staging, temporary support, bracing required for all permanent and temporary structures.
 - vii. All tools, plants and equipments / machinery
 - viii. All other consumables including fuel and lubricants etc.
 - ix. All safety and protection arrangements to be made at site / storage yards for road users, public, and workmen.

SECTION- S.08

8. PILE FOUNDATIONS

8.1 General

All piles shall be RCC bored cast in situ reinforced concrete piles.

8.1.1 Piling plant and Methods

Suggested method for piling is cast in situ-bored piles with hydraulic drilling rigs using 4.5m. Depth casing by oscillator or vibro hammer arrangement,

1. Not less than 2 weeks before any piling work is commenced the Contractor shall submit to the Engineer for approval full details of his proposed piling plant, polymer slurry mixing, handling, transporting and disposal scheme and detailed method statements for carrying out the Works.

Details of casings and concreting methods in respect of bored cast in place concrete piles are to be provided.

2. The Contractor shall not commence any piling until the plant and methods which he proposes to use including polymer slurry mixing, handling, transporting and disposal scheme have been approved by the Engineer but such approval shall not relieve the **Contractor** from any of his obligations and responsibilities under the Contract. If for any reason the Contractor wishes to make any change in the plant and methods of working which have been approved by the Engineer, he shall not make any such change without having first obtained the Engineer approval thereof.
3. List and nos. of equipments & accessories proposed to be used for the present job shall be submitted along with the bid.

8.1.2 Records

The Contractor shall keep complete records of all data required by the Engineer covering the fabrication; driving and installation of each pile and shall submit two signed copies of these records to the Engineer not later than noon of the next working day after installation of the piles.

The following data shall be recorded during install align of pile along with any other relevant data as directed by the Engineer.

- i) Sequence of installation of piles
- ii) Dimensions of the pile, including reinforcement details and mark of the pile.
- iii) Depth bored and founding level along with a bore log indicating nature of stratum
- iv) Method of cleaning bottom of hole at founding level before commencing the concreting.
- v) Time taken in concreting
- vi) Cut-off level/working level/RL of top of concrete
- vii) No. of cement bags consumed. Slump of concrete.
- viii) Details of insertion and taking out of tremie pipes i.e. their number, length and sequence.
- ix) Actual sounding before commencing the concrete.

8.1.3 Programme and Progress Report

1. The Contractor shall inform the Engineer each day of the programme of piling for the following day and shall give adequate notice of his intention to work outside normal hours and at weekends, where approved.
2. The Contractor shall submit to the Engineer on the first day of each week, or on such other date as the Engineer may decide, a progress report showing the rate of progress to that date and progress during the previous week or period of all main items of piling works, as required by the Engineer.

8.1.4 Setting Out

The Contractor shall establish and maintain permanent datum level points, base lines and grid lines to the satisfaction of the Engineer and shall set out, with a suitable identifiable pin or marker, the position of each pile. The setting out of each pile shall be agreed with the Engineer at least 8 working hours prior to commencing work on a pile and adequate notice for checking shall be given by the contractor.

Notwithstanding such checking and agreement, the Contractor shall be responsible for the correct and proper setting out of the piles and for the correctness of the positions, levels, dimensions, and alignment of the piles.

- 8.1.5** After all piles are cast in a pile cap and weak concrete is chipped out, the Contractor shall submit the drawing showing the exact location of piles with respect to the column centre line.

8.1.6 Disturbances and Noise

1. The Contractor shall carry out the piling work in such a manner and at such times as to minimise noise, vibrations and disturbance. Noise limit as prescribed in "Building and other Construction Workers Act-Schedule-VI" shall be referred.
2. The Contractor shall take precautions adequate enough to avoid damage to existing services and adjacent structures. Fig.1 of IS:2974 (Part 1) - 1969 may be used as a guide for studying qualitatively the effect of vibration on persons and structures. In case of deep excavation adjacent to buildings/structures, proper shoring or other suitable arrangement shall be done to guard against the lateral movement of soil stratum or releasing the confining soil stress. Any such damage if caused shall be repaired by the contractor at his own cost to the entire satisfaction of the Engineer.
3. The Contractor shall ensure that damage does not occur to completed piling works and shall submit to the Engineer for approval his proposed sequence and timing for driving or boring piles having regard to the avoidance of damage to adjacent piles.

8.1.7 Obstructions

If during the execution of the Works the Contractor encounters obstructions in the ground, he shall forthwith notify the Engineer accordingly, submit to him details of proposed methods for overcoming the obstruction and proceed according to the Engineer's instructions at no cost to the employer.

8.2 Scope of Work

- 8.2.1** These specifications cover the works of providing pile foundations. Work included consists of all necessary services and furnishing of all labour material, tools, plant, equipment and related items for the full and satisfactory performance of the contract, conforming to these specifications and as shown in the Contract Drawings or reasonably implied therein or any authorised conditions or alterations thereof.
- 8.2.2** The tenderer is advised to visit the site and familiarise himself with the conditions at site. The Engineer shall not be held responsible for the accuracy of the soil data, furnished in good faith with the tender.
- 8.2.3** The construction of piles shall be in accordance with the following Indian Standard Codes of Practice for Design and Construction of Pile Foundations: IS:2911-1979 Part I Section 2 Bored Cast in-situ Concrete Piles Or IRC:78 Standard specifications and code of practice for road bridges Foundation and Substructure.
- 8.2.4** With the tender, the Contractor shall submit the detailed method of construction to be adopted. For cast-in-situ concrete piles, the Contractor shall indicate the methods he proposes to concrete the piles in order to prevent necking of piles.
- 8.2.5** The Contractor shall quote rates as detailed in the Bill of Quantities and Rates. In particular:
- For piles, the rate quoted shall be for 'per metre length of pile. The actual length of piles will be determined from site conditions and load test results after work begins.
 - In case the load tests and actual site conditions reveal that the piles proposed do not, in the opinion of the Engineer provide a satisfactory and economical foundation, the Engineer at his sole and absolute discretion shall have the powers to revise the pile layout. (Dia of piles will not be changed, however number of piles may get changed)
- 8.2.6** The items of work to be carried out in piling will generally be:
- Boring/drilling including provision of temporary casing (including its withdrawal), empty boring, & polymer slurry,
 - Supplying, fabrication, tying and placement of all reinforcement.
 - Casting of concrete piles as per specifications.
 - Integrity and Load testing of piles.

8.3 Materials

8.3.1 General

Unless otherwise specified in this section all materials shall conform to the requirements specified in separate sections for Concrete, Formwork and Reinforcement.

8.3.2 Cement

The cement to be used for piling and all foundation work shall be conforming to following Indian Standard Specifications:

IS: 455: Specification for Portland slag cement

However, if the soil and ground water conditions are found Ok on chemical testing in labs, Ordinary Portland Cement of 53grade may also be used as per codal provisions.

Cement shall be free from lumps and caking.

8.3.3 Concrete Mix Design

The concrete shall generally be of grade M35. The maximum size of coarse aggregate shall not exceed 20mm. For cast-in-situ piles concrete with a slump of 150 to 175mm (consistent with the method of concreting) will be required. Minimum cement content for design mix shall not be less than 400 kg/m³ of concrete in piling. For piling, qty of cement to be used shall be as per the design mix or the minimum cement content whichever is greater.

The contractor shall submit mix design calculations and get the same approved by the Engineer well before the starting of boring of piles and carry out adequate numbers of tests to ensure the minimum specified strength as indicated in drawings.

8.3.4 Concrete cube tests

Concrete cubes shall be cast, tested and evaluated as specified in Section 3.

8.3.5 Reinforcement

- (a) The reinforcement shall conform to the requirements specified in Section 5 extending for the full length of the pile and shall project 60 times bar diameters above the cut off level or as specified in the drawing. Only circular concrete cover blocks threaded on to the helix shall be used for ensuring the specified cover.
- (b) Joints in main longitudinal bars will be permitted only where, in the opinion of the Engineer, each bar cannot be supplied in one complete length. Where permitted, laps with full welding shall be provided as per the design/ drawings to develop the full strength of the bar across the joint, provided with adequate extra links or stirrups in position from those of adjacent longitudinal bars, all to the approval of the Engineer. No extra payment on account of providing laps shall be paid. The cost towards steel consumed in laps shall be considered in the BOQ rates.
- (c) All main longitudinal bars shall be welded at lapping and to the pile cap reinforcement. The last circle of helical stirrups at each end shall be welded to main longitudinal bars. Nothing extra shall be payable on account of this. Any extra tack welding required for handling and lowering of cage in borehole shall also be done by the contractor at no extra cost.

8.3.6 Casings and Tremie Pipes

The casings and tremie pipes shall be in mild steel. The temporary casing plates of 4.5m. Length and permanent liners shall have adequate wall thickness and strength to withstand driving stresses, stresses due to soil pressure, etc. Without damage or distortion all joints shall be water tight. The internal diameter of the casing shall not be less than the nominal diameter of pile.

8.4 Cast In-Situ Bored Piles

8.4.1 General

- (a) Diameters of the piles shall be the concrete shaft diameters and shall not be less than the diameters specified in the drawing.
- (b) These shall be formed by boring to the founding strata specified on the drawings or as directed at site. The sides of the boring shall be prevented from collapsing by one of the following

Providing permanent mild steel liner (cased pile)

Providing removable mild steel casing (uncased pile)

- (c) Piles shall be constructed in a sequence approved by the Engineer. During boring, the Contractor shall, where required by the Engineer, take soil, rock or ground water samples and transport them to an approved testing laboratory or carry out soil tests as directed.
- (d) The method adopted shall be chosen giving due consideration to the subsoil data, ground water conditions and to the other relevant conditions at site as well as to the presence of adjacent structures.
- (e) The bottom of the steel lining shall be sufficiently in advance of the boring tool so as to prevent settlement of outside soil and formation of cavities.
- (f) Removable mild steel casings shall be used, only with extreme caution. Individual casings shall be joined together by screwing or any other approved method and not by direct butting with external lug connections. The inner surface of casings shall be smooth and free of all internal projections.

8.4.2 Boring

- (i) Boring shall be done using Rotary hydraulic drilling rigs with oscillator arrangement / equipments and methodology suitable for different kinds of strata encountered.
- (ii) As a general guideline, size of cutting tool shall in no case be less than the diameter of the pile minus 75mm. However, the size of cutting tool shall be chosen by contractor depending on the type of substrata and equipment employed by contractor so that executable pile shall not have diameter less than nominal diameter of pile as specified in drawing. The contractor shall also ensure that there is no reduction in poured concrete quantities. These calculations shall be based on consumption of concrete poured in bore (as recorded in pour log) and actual concrete required in bore on theoretical basis i.e. based on nominal diameter of pile and actual bore hole length (based on actual sounding of founding level). More than 5% reduction in consumption of poured concrete quantities in pile may be rejected. In general, piling shall be done by using hydraulic rig with temporary liner. Use of liner for top 4.5 meters from ground level or upto depth having N. value (Minim) 10 (to protect loose soil falling in bore hole) as directed by Engineer, is essential. No extra payment shall be made to the contractor for using temporary liner, over the item of piling as in BOQ.
- (iii) Use of Polymer slurry in stabilizing sides of the pile borehole may also be necessary together with temporary or permanent casing wherever sub soil and ground water conditions are likely to cause mud flows or instability of pile bore or sand boiling. However, this will be permitted only when deemed necessary by the Engineer. In such situations the properties of Polymer used & quality control shall be as per requirement given below.

Fresh polymer slurry shall satisfy the following properties at all times:

Mud density shall not exceed 1.05 g/cc

PH Value to be 9 to 11.5

Marsh Cone viscosity 30-40 seconds

The sand content of Size > 0.075mm shall not be more than 1 Percent.

When borehole is stabilised by casing and drilling mud or by maintaining water head using temporary/permanent casing, the bottom of the hole shall be cleaned very carefully before concreting work is taken up. Cleaning / flushing methodology shall be submitted and got approved by the engineer prior to commencement of piling.

The quantum of steel required in permanent liners from the cut off level downwards shall be measured as per drawing. Though the liner might have been provided right from the level of the working platform on practical considerations, the length of the permanent liner above the cut-off level has to be necessarily removed for facilitating chipping of the top portion of the pile and for interlacing its reinforcement bars into the capping slab. There is however, no objection if the surplus pieces (if cut and removed carefully and then found reusable) are joined and are re-welded to required length for reuse in the same contract on some of the other piles. No claim / compensation shall be entertained for such cut pieces if they cannot be reused by the Contractor in the aforesaid manner.

- (iv) Pumping from a bore hole shall not be permitted unless a casing has been driven into a stable stratum which prevents flow of external ground water from other strata in significant quantities.
- (v) In case of end bearing piles founded on rock, cutting of rock by hydraulic rig using diamond bits will be resorted to. Scheme adopted shall be such that noise and vibration parameters specified in tender document /Environment manual are not violated. Drilling in rock shall be carried out by hydraulic rig using diamond bits.
- (vi) On completion of boring, loose disturbed or remolded soil shall be removed from the base of bore.
- (vii) In case of dry bores inspection shall be carried out from the ground surface for bores having diameter less than 750mm. For larger diameter bores equipment shall be provided to enable the Contractor and the Engineer or their representatives to descend into the boring for the purpose of inspection

Penalty on mishandling of Polymer

Mishandling of Polymer (like splashing of Polymer outside specified width of barricading or non-cleaning of tyres of dumpers and transit mixers before leaving the piling site thereby making the road dirty etc.) is strictly prohibited. Noncompliance of same shall attract a penalty as follows:

- (i) On first observation –Rs. one lakh
- (ii) On Second observation –Rs. two lakhs
- (iii) On third and each subsequent observation – Rs. three lakhs

8.4.3 Concreting

- (a) Prolonged delays in the commencement of concreting after the completion of the boring shall not be permitted. The time interval between the completion of boring and placing of concrete shall not exceed 6 hours.
- (b) The concrete shall have a minimum slump of 150 mm. Suitable precautions shall be taken for prevention of segregation. Internal vibrators shall not be used unless the Contractor is satisfied that segregation will not result because of vibration and unless the method of use has been approved by the Engineer.
- (c) The concrete for piles underwater or in drilling mud shall be placed with a tremie pipe. The tremie pipe shall not be less than 200mm diameter for 20mm aggregate. The joint between the hopper and tremie pipe as well as the joints in the tremie pipe shall be water tight and the tremie pipes shall be thoroughly cleaned after each use.

It is essential that the water level within the pile bore be in equilibrium before commencement of concreting.

- (d) The Contractor shall ensure that heavily contaminated drilling mud has not accumulated at the base of boring since this could impair free flow of concrete from the tremie pipe.
- (e) If the specific gravity of the drilling mud at the base of the bore exceeds 1.20 the placing of concrete shall not proceed.
- (f) The first charge of concrete shall be placed in the hopper over a sliding plate of the bottom of the hopper. The charge should be adequate in volume to ensure flushing action to prevent mixing of water or drilling mud and concrete. Alternatively floating plugs of approved specification may be used before the first charge of concrete.
- (g) The tremie pipe shall at all times penetrate the previously placed concrete for minimum depth of 2 m as a precaution against accidental withdrawal. The tremie pipe shall not be withdrawn until the completion of concreting. At all times a sufficient quantity of concrete shall be maintained within the pipe to ensure that the pressure from it exceeds that from the seepage water.
- (h) Spot measurements shall be taken at suitable intervals to check that the tremie pipe has an adequate penetration into previously placed concrete.
- (i) Concreting of the pile shall be in one single and continuous operation. In case of long piles of large diameter, large size mixers or more number of mixers shall be used so that the entire concreting operation is completed in not more than two hours.
- (j) The top of concrete in a pile shall be brought above the cut-off level since the top concrete is loose and is weak because of contamination with water/drilling mud. This ensures good concrete at the cut-off level.
- (k) Cut off level (COL)

Cut off level of piles (75mm inside the pile cap) shall be as indicated in working drawings or as indicated by Engineer.

The top of concrete in pile shall be brought above the cut off level to remove all laitance & weak concrete and to ensure good concrete at cut-off level.

In case of concrete being placed by tremie method and pile cut off level being less than 1.0meter below the ground level, concrete shall be cast to the piling platform level to permit overflow of concrete for visual inspection. In case COL of pile is more than 1.0 meter below working level then concrete shall be cast to a minimum of one meter above COL. Before concreting contractor shall obtain the approval of the Engineer of the height above COL up to which the concrete is to be cast.

In the circumstances where COL is below ground water level, the need to maintain a pressure should be observed & accordingly length of extra concrete above COL shall be determined by the Contractor and approval of Engineer obtained before concreting.

Any defective concrete in the head of the completed pile shall be cut away and made good with new concrete.

- (l) When a casing is being extracted, sufficient quantity of concrete shall be maintained within the bore to ensure the pressure from external ground water and soil is adequately exceeded by the pressure of concrete. Otherwise necking of the pile may result.

- (m) No concreting shall be placed in the bore once the bottom of the casing has been lifted above the top of concrete.
- (n) While concreting the pile, the overflowing Polymer slurry from pile should be carefully pumped out to a water tight container/tank so that it does not spill over. The contaminated Polymer should be disposed off as per the methodology approved by the Engineer.
- (o) After each pile has been cast any empty bore shall be protected by putting steel cage/Jali over it and carefully backfilled as soon as possible with approved materials.
- (p) Complete boring and concreting records shall be submitted to the Engineer for each pile. The records shall include the duration of concreting, tremie lengths (individual and cumulative), tremie pipe lengths removed, theoretical sounding, actual sounding, actual lengths of pile concreted and the volume of concrete placed, cut off level, founding levels etc. For piles with temporary casings records of sequence of casing withdrawal and levels of concrete before and after withdrawal shall also be included in the reports.
Generally, the COL is 2.5 m below the exiting ground level however, if any utility has to be placed on top of the pile cap, the COL may vary according to the requirement at that specific location.

8.5 Alignment of Piles

8.5.1 Piles shall be installed as accurately as possible according to the drawings either vertically or to the specified batter. All deviations will be measured at the cut off level of the piles. The deviation from the true axis shall not be more than 1.5% for vertical piles and 4% for raker piles. Piles should not deviate in location by more than 75mm when used in groups. For single or two piles used under piers / columns, deviation shall not be more than 50mm.

8.5.2 The Contractor shall maintain a record of actual pile locations in the form of a drawing and submit the information to the Engineer at suitable intervals.

8.6 Pile Cap

Pile caps shall be of reinforced concrete. A minimum offset of as shown in the drawings shall be provided beyond the outer faces of the outer most piles in the group. If the pile cap is in contact with earth at the bottom, a levelling course of minimum 75 mm thickness of PCC of grade M20 shall be provided or as shown in the drawings.

The attachment of the pile head to the cap shall be adequate for the transmission of loads and forces. A portion of pile top may be stripped of concrete and the reinforcement anchored into the cap. Manual chipping may be permitted after three days of pile casting while pneumatic tools for chipping shall not be used before seven days after pile casting. The top of pile after stripping shall project at least 75mm into the pile cap. Concreting of the pile cap shall be carried out in dry conditions. Nothing extra will be paid for dewatering, etc. for carrying out pile cap excavation. Cost of all the operations and tools required for making the pile cap in dry condition is deemed to be included in the item.

The road surface after casting of pile cap should be repaired immediately. If the surface is not repaired immediately, penalty will be imposed as decided by the Engineer.

8.7 Testing of Piles (STANDS DELETED)

8.1 Defective Piles

- 8.8.1 The Engineer reserves the right to reject any pile which in his opinion has not been constructed in accordance with the specifications.
- 8.8.2 The Contractor will not be paid for rejected piles. The increase in cost of the pile caps, tie beams and other measures adopted for strengthening as a result of rejection of defective piles shall be borne by the Contractor.

8.2 Mode of Measurement of Piles

8.9.1 Piles with casing pipe / Temporary Liners

- 1 The Contractor shall be paid for the length of each pile as measured from the theoretical founding level (as per drawing) or as per actual whichever is less to the point of the vertical cut-off level. The Contractor's rate shall include all items of work including all temporary/permanent arrangements for boring including usage of Polymer, chiseling as specified / required, concreting, handling, form-work and grouting for precast piles, including chipping of top weak concrete, cutting off the MS liner / casing as necessary, removal of excavated earth, chipped concrete, casing / liners and Polymer slurry away from site including its treatment & final disposal, and all other items of work for the satisfactory completion of the pile foundations. Reinforcement shall be measured and paid separately.
- 2 Pile load tests initial and routine shall be measured separately and paid for separately.
- 3 Each pile integrity test shall be measured and paid for separately.
- 4 The quoted rate should include costs of tools and plants, cutting, welding MS liner, cutting shoe etc. complete.

Attention is also drawn to Para 8.4 2 (c) above.

8.9.2 Piles with Permanent Liners

The quantity of piles with permanent steel liners (6 mm thick mild steel) required for the job shall be measured as per specifications / detailed in para 8.9.1 (1) above and paid for separately as per the relevant item of BOQ. In case 8 mm plates are used 30% enhancement over accepted rate will be paid.

Attention is also drawn to Para 8.4 2 (c) above.

8.3 As-Built Drawings

On completion of the work, the Contractor will submit a plan showing the exact location and length of each pile as constructed at site, as well as dates of concreting, cube test results etc. The original tracings of these drawings along with soft copies shall be submitted to the Engineer.

8.4 The Termination Criteria:

The Termination of Pile for rock anchoring, Contractor shall follow any of following criteria's:-

- (A) Contractor shall use minimum 3.6 t weight of the chisel for socket length in soft rock / hard rock. In case the Contractor uses 3.6t chisel the termination criteria shall be as follows:
- The Penetration in rock in 900 blows with height of 1.5m is:
- a) Between 20 – 40 cm, then rock will be called 'Soft Rock' and anchoring shall be 2.5 dia of Pile
 - b) less than 20cm, then rock will be called 'Hard Rock' and anchoring shall be 1 dia of Pile.

Or

- (B) For the purpose of socketing of end bearing pile in soft / hard rock, the following alternative criteria can be adopted to determine the soft/hard rock.
- Rock will qualify as soft rock if RQD = 35% and core recovery=35% and core strength 35Mpa ~ 350T/M².
 - rock will qualify as hard rock if RQD =75% and core recovery =75% and core strength 50 Mpa and above i.e. more than 500 T/ M²

Note: Termination level of pile will be decided by Engineer based on above criteria or any other Standard practice based on Energy criteria.

SECTION- S.09

9. ROOF SHEETING (Stands deleted)

SECTION- S.10

10. OTHER WORKS

10.1 Bearings

10.1.1 General

This work shall consist of design supply and fixing in position of bearings for bridge/viaduct girders in accordance with details shown on drawings and to the requirements of these Specifications, Codes and Standards quoted therein and as directed by Engineer.

- 10.1.1.1 Bearing plates, assemblies and other expansion or fixed devices shall be constructed in accordance with details shown on drawings.

When bearing assemblies or plates are shown on drawings to be placed (not embedded) directly on concrete, the concrete bearing area shall be constructed slightly above grade and shall be finished by grinding.

- 10.1.1.2 It shall be ensured that the bearings are set truly level and in exact position as indicated on drawings so as to have full and even bearing on the seats. This shall be checked with spirit level in both directions. Thin epoxy mortar pads (not exceeding 5 mm) may be made to meet with this requirement.

It shall be ensured that the bottoms of girders to be received on the bearings are plane at the location of these bearings and care shall be taken that the bearings are not displaced while placing the girders.

- 10.1.1.3 When elastomeric bearing pads or preformed fabric pads are to be provided, the concrete surfaces on which pads are to be placed shall be wood float finished to a level plane, which shall not vary by more than 1.5 mm from a straight edge placed in any direction across the area.

- 10.1.1.4 All bearings shall carry a warrantee of not less than 15 years in an approved format. The contractor shall be responsible for immediate repair or replacement of the bearings in case of failure / distress to the satisfaction of the BMRCL at no extra cost to the BMRCL within the warrantee period.

10.1.2 Scope Of Work

The scope of work will include:

- I Rendering necessary assistance/coordinate with the manufacturer with regard to placement/fixing of said bearings. The contractor shall ensure that these bearings are installed in accordance with the specification of the manufacturers so that the bearings perform in the desired manner, in accordance with the forces/ displacements/ rotations for which these bearings have been designed. The contractor shall liaise with the agency and will be responsible for design etc. The contractor shall furnish adequate and proper installation details for these bearings while submitting his design and detailed Engineering Drawings. The design criteria, specifications etc. as mentioned in tender documents are mandatory and no deviation to the same shall be permitted unless otherwise directed by the Engineer.
- II The contractor shall supply all the bearings in suitable packed condition (for its proper transportation and storage before placement in position) at project site to be identified by the Engineer. The price for such bearings (quoted in Schedule of Quantities) shall include all the accessories/holding down bolts/fixing arrangements (excepting reinforced concrete work in piers and girders, and finishing the surfaces of the pedestal) including grouting of holes with epoxy etc., as required.

A. POT BEARINGS**A.1 Material specifications of Pot bearing**

The material such as PTFE (Poly Tetra Fluoro Ethylene) and lubrication to be used in Pot bearing should conform to BS: 5400 Part-9.2 & BS: 3784. The confined elastomer to be used shall conform to IRC: 83 with a minimum IRHN of 60 +/- 5. The stainless steel shall conform to AISI: 304. The Pot base, saddle & top plate shall be of Cast steel conforming to IS: 1030 Gr 280-520 W. Structural steel shall conform to grade A IS: 2062-1992. The POT cylinder shall be made up of cast steel. If POT cylinder is to be made of mild steel, then it shall be made of Mild Steel conforming to Grade A of IS: 2062 - 1992 and without welding, duly certified as lamination free steel from SAIL/TISCO. No building up of thickness shall be permitted for POT cylinder. The anchor bolts shall conform to IS: 1364. All welding will be done by manual arc process and as per approved drawing shall conform to IS: 816 & IS: 9595 with electrode as per IS: 814. Pre-healing and post weld stress relieving shall be done as per IS: 9595. Painting on non-working surface of bearing shall be as per MoRT&H specification, cl 2006.4.5. The mating surface of Piston and cylinder shall be hardened to 350BHN (Min).

A.1.1 ELASTOMER –Only the required type of chloroprene viz. Neoprene- WRT, Bayprene 110 or equivalent as specified in IRC:83 (Part-II)-1987 shall be used in the manufacture of bearings. The Chloroprene shall either be imported directly from the manufacturers or purchased from their authorized agent in India and shall give a certificate to this effect to the department and the same shall be verified from the documents of purchase. Only fresh chloroprene which has been produced not earlier than one year shall be permitted for manufacture of bearings. No reclaimed rubber or vulcassired wastes shall be used.

A.1.1.1 The confined elastomer inside the POT will have the following properties as per Clause 2006.3(c) of MoRT&H Specifications for Roads and Bridges which is reproduced below (Test method as per IS: 3400).

(a)	Hardness	IRHD	50+5
(b)	Tensile strength (minimum)		15.5 Mpa
(c)	Elongation at break (minimum)		400%
(d)	Compression set (maximum)		35%
(e)	Accelerated ageing (maximum Change from initial value)		
(i)	Hardness	(+)	15 IRHD
(ii)	Tensile Strength	(-)	15%
(iii)	Elongation at Break	(-)	40%

Other specifications as given in IRC: 83 (Part II) for elastomeric bearings will be followed.

A.1.1.2 The elastomer for guide-stopper bearing shall be of synthetic rubber (Chloroprene) and shall conform to all the properties specified in clause 915.2 of IRC: 83 (Part – II) – 1987.

Laminates of mild steel conforming to IS: 226 shall only be permitted to be need. Use of any other materials like fiber glass or similar fabric as laminates shall not be permitted.

A.1.2 Accessories other than those mentioned below will be as per IS: 2062 – 1992.

- (a) Sealing ring for POT – Metallic (brass).
- (b) Wiper seal – elastomer as per IRC: 83 (Part - II) - 1987.
- (c) Dust seal – elastomer as per IRC: 83 (Part II) - 1987.

Guide stop bearings shall be fabricated as per tolerances in Table 2 of IRC: 83 (Part-II)-1987.

Design of the bearing and all accessories shall be the responsibility of the Contractor and got approved from the Engineer.

A.2 Permissible stresses in steel component of Pot bearing

All the design requirement for Pot bearing as specified in IRC: 83 Part-III has to be fulfilled with following modifications.

(a) No increase in permissible stresses in any material of bearing or bearing stress between concrete and bearing is permitted in seismic condition.

A.3 Permissible bearing stresses in concrete

The allowable bearing stresses in concrete as defined in IRC:83 Part-III has to be followed with following modifications.

No increase in permissible bearing stress between concrete and bearing is permitted in seismic condition.

A.4 Anchor sleeve

All the part of bearing such as anchor sleeves embedded in concrete shall be hot dip galvanized @ 300gm/ m². The anchor sleeves has to be designed taking account of difference in elasticity of steel of sleeve and concrete. The effect of shifting of center of rotation of sleeve should be also taken into account.

A.5 The contractor shall furnish along with tender documents in technical bid, the name of the manufacturer of bearings, his qualifications with all details including proof of satisfactory performance, certification and testing facilities of the bearing he proposes to use. Products of reputed manufacturers shall only be used.

A.6 The Bearings shall be measured in numbers according to their capacities. For this purpose Fixed type POT bearings, Free sliding type POT-cum-PTFE bearings, Guided sliding type POT-cum-PTFE bearings, Free or Guided PTFE Sliding Assembly, Pin Bearings or Metallic Guided bearings shall be counted separately. The rate shall include the cost of supplying, fixing, sampling and testing as required and confirming to the specifications.

A.7 Testing of Pot Bearing

A.7.1 Proof Load Test

A test bearing shall be loaded to 150% of the bearing's rated design capacity and simultaneously subjected to a rotational range of 0.02 radians or design rotation, whichever is greater, for a period of one hour.

The bearing will be visually examined both during the test and upon disassembly after the test. Any resultant visual defects, such as extruded or deformed elastomer or PTFE, damaged seals, or cracked steel, shall be cause for rejection.

During the test, the steel bearing plate and steel piston shall maintain continuous and uniform contact for the duration of the test. Any observed lift-off will be cause for rejection.

All bearings will be applied with a vertical load perpendicular to the plan area of the bearings and on approved system duly approved by Engineer, to subject the bearings to rotation. The minimum load at which the required rotation is achieved is to be determined and this value should be less than the minimum design vertical load as tabulated in the drawing.

For guide-stopper bearing, test on specially molded test pieces shall be conducted as per clause 918.4.1.2. of IRC : 83 (Part – II) – 1987 which shall be compared with Test pieces from test bearings. The variation shall be within limits specified herein.

A.7.2 Sliding Coefficient of Friction

For all guided and non-guided expansion type bearing, the sliding coefficients of friction shall be measured at the bearing's design capacity.

The sliding coefficient of friction shall be calculated as the horizontal load required to maintain continuous sliding of one bearing, divided by the bearing's vertical design capacity.

The test result will be evaluated as follows:-

- (a) The measured sliding coefficients of friction shall not exceed 3%.
- (b) The bearing will be visually examined both during and after the test. Any resultant visual defects, such as bond failure, physical destruction, cold flow of PTFE to the point of debonding, or damaged components shall be cause for rejection.

A.8 Sampling and Testing

A.8.1 Lot Size

Sampling, testing and acceptance consideration will be made on a lot basis. A lot shall be defined as those bearings presented for inspection at a specific time or date. A lot shall be further defined as the smallest number of bearings as determined by the following criteria.

- (a) A lot shall not exceed a single contract or project quantity;
- (b) A lot shall not exceed 25 bearings;
- (c) A lot shall consist of bearings of the same type regardless of load capacity. Bearing types shall be fixed or expansion bearings types. Guided and non-guided expansion bearing shall be considered a single type.

A.8.2 Sampling and testing requirements

The manufacture shall furnish the required number of samples to perform testing in accordance with Table Given below:-

Sampling and Testing Requirement

Test	Sample Required
Proof load	One production bearing per lot
Coefficient of Friction	One production bearing per lot
Physical Properties of elastomeric rotational elements	One elastomeric element per lot
Physical properties of PTFE sheet	One 10" x 15" sheet of PTFE material per project

A minimum of thirty (30) days shall be allowed for inspection, sampling and testing of production bearings and component materials.

All exterior surfaces of sampled production bearings shall be smooth and free from irregularities or protrusions that might interfere with testing procedures.

The manufacturer shall select, at random, the required sample bearing(s) from completed lots of bearings for testing by the manufacturer. He shall complete the required testing and determine compliance with this specification before submitting the lot(s) for inspection, sampling, and acceptance consideration.

The Engineer shall select, at random, the required sample bearing(s) from completed lots of bearings.

Necessary test certificates for all raw material shall be furnished by manufacturer .Test specified in IS:1030 for cast steel shall be performed. Casting shall be ultrasonically got tested by approved testing agency.

A.9 Fabrication Details

The Contractor shall provide the Engineer with written notification thirty (30) days prior to the start of bearing fabrication. This notification shall include all the information shown on the shop drawings which are required as explained in subsequent section.

The finish of the mold used to produce the elastomeric rotational element shall conform to good machine shop practice.

All steel surfaces exposed to the atmosphere, except stainless steel surfaces and metal surfaces to be welded, shall be shop painted in accordance with the Contract Plans. Prior to painting, the exposed steel surfaces shall be cleaned in accordance with the recommendations of the coating's manufacturer. Metal surfaces to be welded shall be given a coat of clear lacquer, or other protective coating approved by the Engineer, if the time of exposure before welding takes place is to exceed three months, the coating shall be removed at the time of welding. No painting will be done to these surfaces prior to the completion of welding.

Stainless steel sheet shall be attached to its steel substrate with an approved epoxy to ensure complete contact and then sealed with a continuous seal weld.

The steel piston and the steel pot shall each be machined from a solid piece of cast steel.

The outside diameter of the piston shall be no more than 1mm less than the inside diameter of the pot at the interface level of the piston and elastomeric rotational element. The sides of the piston shall be beveled to facilitate rotation. Except as noted all bearing surfaces of steel plates shall be finished or machined flat in accordance with tolerance given below:

Tolerances :-

Manufacture tolerance shall be as per IRC:83 Part-III and BS:5400,section 9.2 shall be followed subject to following modification .

(a) Plan Dimension:	-0 to +5mm
(b) Overall height:	-0 to +3 mm
(c) Height of any steel component	
(i) Machined	-0 to 0.5mm
(ii) Unmachined	class 2 of IS:4897
(d) Stainless steel sliding surface	
a. Flatness	0.0004L , where L= length in direction of measurement
b. Surface Finish	Ra shall be less than or equal to 0.25 µm as per IS: 3073

All the measurements will be taken using dial / height gauges , vernier calipers, surface finish measurement instrument etc has to be arranged by manufacturer at the workshop.

Every bearing shall have the Project Identification Number, Lot Number, and individual bearing number indelibly marked with ink on a side that will be visible after erection.

After assembly, bearing components shall be held together with steel strapping, or other means, to prevent disassembly until the time of installation. Packaging shall be adequate to prevent damage from impact as well as from dust and moisture contamination during transportation and storage.

A.10

Shop Drawings

Along with detailed design of different types of bearing , shop drawings shall be submitted. The shop drawings shall contain the following information, which is necessary for proper design and detailing of the bearings.

Quantity, type (fixed, guided expansion, non-guided expansion), and location of all bearing

units.

A table containing maximum and minimum vertical and horizontal loads, design rotation requirements, and magnitudes and directions of movements.

Allowable contact stresses, maximum dimensions, and anchorage requirements at the bearing interfaces; grades, bevels, and slopes at all bearings; and allowable coefficients or friction of all sliding surfaces.

The painting system to be used on the steel components to guard against corrosion.

Any special consideration such as earthquake requirements, uplift details, or temporary attachments.

Installation scheme of pot bearing.

The Contractor shall submit detailed shop drawings in conformance with the applicable requirements.

A.11 Measurements

The bearings will be counted in numbers along with bolts & washers.

SPHERICAL BEARINGS

Spherical bearings consisting of a metal piston supported by a disc, sealing rings, dust seals, steel mating surface, Complete as per IRC83-2014 Part (IV) and as per drawing and approved Technical Specifications. The design of the bearings shall be submitted by the manufacturers/ contractor and got approved from BMRCL before fixing. Test report of the bearings should be got approved before the materials are lifted from the manufacturer premises.

B. ELASTOMERIC BEARINGS

The term "bearing" in this case refers to an elastomeric bearing consisting of one or more internal layers of elastomeric bonded to internal steel laminates by the process of vulcanization. The bearing shall cater for translation and/or rotation of the superstructure by elastic deformation.

B.1 Raw Material

The raw material shall conform to the requirements laid down in EN 1337-3:2005 (E) or latest.

Chloroprene (CR) only shall be used in the manufacture of bearing.

No reclaimed rubber or vulcanized wastes or natural rubber shall be used.

EPDM and other similar candidate elastomers for bridge bearing use shall not be permitted.

B.2 Properties

The elastomeric shall conform to the properties specified in EN 1337-3:2005 (E) or latest. The design, drawings, detailed method statement for installation & replacement of the bearings including its accessories shall be the responsibility of the Contractor. The design shall be got checked and certified by approved independent agency before submitting to the Engineer for approval.

B.3 Fabrication and Tolerances

Fabrication and Dimensional requirements shall be satisfy the requirement the relevant codes and specifications and in general shall be complying to the European Standard in EN 1337-3:2005 (E) or latest.

B.4 Acceptance Specifications

Sampling testing and acceptance consideration will be made on a lot basis all as specified in European Standard in EN 1337-3:2005 (E) or latest. A lot shall be defined as those bearings presented for inspection at a specific time or date. A lot shall be further defined as the smallest number of bearings as determined by the following criteria.

- (a) A lot shall not exceed a single contract or project quantity;
- (b) A lot shall not exceed 50 bearings;
- (c) A lot shall consist of bearings of the same type regardless of load capacity.

In addition to tests mentioned above, all bearings shall also be weighed actually and compared with the theoretical weight.

B.5 Design

The design of elastomeric bearings shall be as per the guidelines laid down in the European Standard in EN 1337-3:2005 (E) or latest.

The design, drawings and detailed method statements for installation and replaceability of the bearings shall be checked and certified by approved independent agency before submitting to the Engineer for approval.

B.6 Storage and Handling

Each elastomeric bearing shall be clearly labelled or marked. The bearing shall be wrapped in a cover. They shall be packed in timber crates with suitable arrangement to prevent movement and to protect corners and edges.

Care shall be taken to avoid mechanical damage, contamination with oil, grease and dirt, undue exposure to sunlight and weather to the bearings during transport and handling prior to and during installation.

B.7 Installation

Installation procedure shall conform to guidelines listed in the IRICEN publication and Clause 2005.6 of the MORTH specifications. Cost of Non-shrink Epoxy grout above and below the bearing ~~should be~~ is included in the cost of providing and installation of bearing as per BOQ.

B.8 Marking and labeling:

Each elastomeric bearing is uniquely and individually numbered on its external faces. As a minimum, a label is valcuanized on the top or bottom on the bearing detailing:

- The manufacturers name
- The manufacturing number and the manufacturer name and symbols on one of the edges.
- Marking shall be resistant to water and normal wear and tear.
- Covering the "C-type" elastomer bearing system, an indelible label carrying the same details as those mentioned on the shelf- valcunizing label. (see above)

Bearing with enhanced very low temperature performance shall be distinctly marked "Very Low Temp".

CE marking:

All elastomeric bearing supplied from manufacturer shall be affixed with CE marking all as specified in EN 1337-3:2005 (E) or latest as a mark of conforming of quality of end product and manufacturer conforms all as per European standard EN 1337-3:2005 (E) or latest.

B.9 Measurement:

Measurement shall be done in cu.cm correct to two decimal places. All linear dimensions required to arrive at volume of elastomeric shall be measured correct to a mm. Payment shall be made for the volume of bearing as per design.

10.2 EXPANSION JOINTS**10.2.1 Scope of Work**

The scope of work will include:

- 10.2.1.1 Preparation of detailed engineering and installation drawings, supply and supervision during fixing of strip seal/compression seal expansion joints conforming to specifications. The expected expansion/contraction of the superstructure at the location of expansion joints are shown in relevant drawings.
- 10.2.1.2 Design, manufacture, providing and seating of expansion joints by the specialized agency and approved by the Engineer.
- 10.2.1.3 Necessary technical supervision for installation of each and every expansion joint during different stages of installation including rectification of any deficiency or defect attributable to fixing and installation will be provided by the manufacturer/supplier.
- 10.2.1.4 The expansion joint shall be provided for the full width of viaduct including the railing.
- 10.2.1.5 Leak tightness of all joints shall be ensured which shall also carry a warranty of 10 years from the contractor.
- 10.2.1.6 The expansion joints provided over elevated structure decks should be so designed as to be compatible with the bearings wherever provided where the structure passes through stations, specially designed completely waterproof expansion joints should be Provided.
- 10.2.1.7 The contractor shall submit design and drawing of compression seal expansion joints based on design criteria mentioned under "scope of Work" to the Engineer for approval. The design of expansion joint shall be done as per Revised Highways "Interim Specification for expansion joint" issued by Ministry of Road Transport vide No. RW/NH - 34059/1/96 - S & R dated 30th November 2000, IRC Codes and MORT&H Specification for Roads and Bridges and Sound Engineering practices.

Any modification to the design and drawings submitted by the Contractor, if suggested by the Engineer, shall be incorporated without any reservations. The design and drawings including changes approved by the Engineer shall form basis of execution and the Contractor shall undertake all necessary action for ensuring execution of work on that basis.

For design, manufacture, testing and supply of strip seal/modular strip seal expansion joints, following will be followed in order of preferences.

- (a) Details in this chapter and elsewhere in tender documents.
- (b) "Revised Interim Specifications for expansion joints" issued by MORT&H vide No. RW/NH – 34059/1/96/ S & R dated. 30.11.2000.
- (c) IRC Codes and MORT&H specifications for Roads and bridges published by Indian Road Congress.
- (d) Sound Engineering Practice (Decision of Engineer will be final in this case) which shall include specialized literature as decided by Engineer.

STRIP SEAL ELEMENT SPECIFICATION

Sealing element is made of chloroprene and must be extruded section. The working movement range of the sealing element shall be 70mm.

Property	Specified Value
Hardness*	
DIN 53505	63+ /-5 Shore A
ASTM D 2240 (Modified)	55 +/- 5 Shore A
Tensile Strength*	
DIN 53504	Min 11 MPa
ASTM D 412	Min 13 .8Mpa
Elongation at fracture*	
DIN 53504	Min 350 per cent
ASTM D 412	Min 250 per cent
Tear Propagation Strength	
Longitudinal	Min 10 N/mm
Transverse	Min 10 N/mm
Shock elasticity	Min 25 per cent
Abrasion	Min 220 Cu.mm
Residual Compressive Strain (22h/70 deg C/30 per cent Strain))	Max 28 per cent
Aging in hot air (14days/70 deg C)	
Change in hardness	Max + 7 Shore A
Change in tensile strength	Max -20 per cent
Change in elongation at fracture	Max - 20 per cent
Ageing in Ozone (24 h/50 pphm/25 deg C/20 per cent elongation)	No cracks
Swelling behaviour in Oil (168h/25 deg. C)	
ASTM Oil No. 1	Max + 5 per cent Max -10 Shore A
Volume Change	
Change in hardness	
	Max + 25 per cent
ASTM Oil No. 3	Max -20 Shore A
Volume Change	Max -35 deg C
Change in hardness	
Cold Hardening Point	

- Only one set of specification viz. ASTM or DIN shall be followed depending on the source of supply.

10.2.2. Building Expansion Joints

Specialised expansion joints consisting of aluminium extrusions and / or elastomer suited to building applications shall be used. These will be provided for covering the structural gap at expansion joints along the horizontal faces of slabs and beams, vertical faces of retaining walls, etc. Necessary block-outs as per the manufacturer's recommendations shall be provided in the structure which shall be filled in the approved manner after placing the expansion joints.

The base of the expansion joint assembly shall be fixed onto the concrete base using anchor fasteners as per manufacturer's specifications. All aluminium in contact with concrete shall have zinc chromate finish. The joint assembly shall be capable of accommodating the specified movement without loss of cover. The expansion joint cover assemblies shall withstand a minimum 500lb point load without damage or permanent deformation.

Only proprietary imported expansion joints from reputed manufacturer's and other MORTH approved manufacturers shall be used.

10.2.3 Fabrication (Pre-installation)

- (a) The strip seal joint system and all its component parts including anchorages shall be supplied by the manufacturer /system supplier.
- (b) The width of the gap to cater for movement due to thermal effect, prestress, shrinkage and creep, superstructure deformations (if any) and sub-structure deformations (if any) shall be determined and intimated to the manufacturer. Depending upon the temperature at which the joint is to be installed, the gap dimension shall be preset.
- (c) Each strip seal expansion joint system shall be fabricated as a single entity unless stage construction or excessive length prohibits monolithic fabrication. It shall fit the full width of the structure as indicated on the approved drawing. The system shall be pre-set by the manufacturer prior to transportation. Presetting shall be done in accordance with the joint opening indicated on the drawing.
- (d) The finally assembled joint shall then be clamped and transported to the work site.

10.2.4 Handling and Storage

- (a) For transportation and storage, auxiliary brackets shall be provided to hold the joint assembly together.
- (b) The manufacturer/supplier shall supply all the materials of strip seal joints including sealants and all other accessories for the effective installation of the jointing.
- (c) Expansion joint material shall be handled with care. It shall be stored under cover on suitable lumber padding.

10.2.5 Supply/Installation:

Components of expansion joint such as edge beam and strip seal shall be imported from the specified foreign manufacturer / collaborator to ensure quality and performance. The joint shall be supplied and installed only by the MORTH approved manufacturer. Contractor shall furnish a warranty of trouble free performance for at least ten years and free rectification of defects / replacement, if any, during this period.

The joints shall be installed by the manufacturer/supplier (only MORTH Approved) or their authorized representative who will ensure compliance to the manufacturer's instructions for installation.

Taking the width of gap for movement of the joint into account, the dimensions of the recess in the decking shall be established in accordance with the drawings or design data of the manufacturer. The surfaces of the recess shall be thoroughly cleaned and all dirt and debris removed. The exposed reinforcement shall be suitably adjusted to permit unobstructed lowering of the joint into the recess.

The shuttering in the recess will be provided in such a way that dimensions in the joint drawing are maintained. The formwork shall be rigid and firm.

Immediately prior to placing the joint, the presetting shall be inspected. Should the actual temperature of the structure be different from the temperature provided for presetting, correction of the presetting shall be done. After adjustment, the brackets shall be tightened again.

The joint shall be lowered in a pre-determined position. Following placement of the joint in the prepared recess, the joint shall be leveled and finally aligned and the anchorage steel on one side of the joint welded to the exposed reinforcement bars of the structure. Upon completion, the same procedure shall be followed for the other side of the joint. With the expansion joint finally held at both sides, the auxiliary brackets shall be released, allowing the joint to take up the movement of the structure.

High quality concrete shall then be filled into the recess. The packing concrete must feature low shrinkage and have the same strength as that of the superstructure, but in any case not less than M40 grade. Good compaction and careful curing of concrete is particularly important. After the concrete has cured, the movable installation brackets and shuttering still in place shall be removed.

The neoprene seal shall be field installed in continuous length spanning the entire carriageway width to ensure proper fit of seal and enhance the ease of installation dirt, spatter or standing water shall be removed from the steel cavity using a brush, scraper or compressed air. The seal shall be installed without any damage to the seal by suitable hand method or machine tools.

The deck surfacing shall be finished flush with the top of the steel sections. The horizontal leg of the edge beam shall be cleaned beforehand. It is particularly important to ensure thorough and careful compaction of the surfacing in order to prevent any premature depression forming in it.

10.2.6 Acceptance Criteria:

- (i) All steel elements shall be finished with corrosion protection system.
- (ii) For neoprene seal, the acceptance test shall conform to the requirements stipulated in Table-1. The manufacturer/supplier shall produce a test certificate conducted in a recognized laboratory, in India (having NABL certification) or abroad.
- (iii) The manufacturer shall produce test certificates indicating that anchorage system had been tested in recognized laboratory having NABL certification to determine optimum configuration of anchorage assembly under dynamic loading.
- (iv) Prior to acceptance, 25 percent of the completed and installed joints, subject to a minimum of one joint, shall be subjected to water tightness test. Water shall be continuously ponded along the entire length for a minimum period of 4 hours for a depth of 25mm above the highest point of deck. The width of ponding shall be at least 50mm beyond the anchorage block of the joint on either side. The depth of water shall not fall below 25mm anytime during the test. A close inspection of the underside of the joint shall not reveal any leakage.
- (v) As strip seal type of joint is specialized in nature, generally of the proprietary type, the manufacturer shall be required to produce evidence of satisfactory performance of this type of joint.

10.2.7 Test and Standards of Acceptance

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria. The manufacturer/supplier shall furnish the requisite certificates from the recognized testing laboratory in India having NABL Certification or abroad.

10.2.8 Mode Of Measurement

The measurement for expansion joints as a finished work shall be in running meters nearest to a centimetre.

10.2.9 Rates

The contract unit rate shall include the cost of all materials, labour, equipment, cost of transportation (overseas as well as with in country), cost of testing including cost of test samples and other incidental charges for fixing the joints complete in all respects as per specifications

10.3 Sealants

10.3.1 General

Joint sealing compounds shall seal joints in concrete against the passage of water, prevent the ingress of grit or other foreign material and protect the joint filler. The compound shall have good

extensibility and adhesion to concrete surfaces and shall be resistant to flow and weathering.

Approved Sealant where specified on the drawings shall be provided strictly in accordance with the manufacturer's written instructions, such joints shall be formed to the correct dimensions, thoroughly cleaned and treated with recommended primer strictly in accordance with the manufacturer's written instructions prior to sealing. Wherever width of gap to be sealed is wide enough to necessitate the use of backer rod, the same shall be provided at no extra cost. The contractor shall use only competent personnel experienced in the application of sealant for such work.

Where specified in the drawings, silicon / polyurethane / polysulphides based sealants shall be of an approved manufacture. The treatment of the joint and the use of sealing compound shall be strictly in accordance with the manufacturer's written instructions. The entire work shall be carried out as per IS:3414, IS:6509, IS:11433.

Sealants shall be as follows:

Silicon sealant shall be one part gun grade type with minimum movement capability of $\pm 25\%$ and elongation at break of 450% confirming to BS 5889 or TTS 001543A. This Sealant shall be of approved colour and shall be nonstaining to the parent concrete surface.

10.3.2 Ancillary Materials

The Contractor shall provide all ancillary materials such as cleaning solutions, epoxy mortar, primer, tool cleaner, bond breaker type, filler boards, back up material, backing rods, polyethylene foam, masking tapes, sealant slot former etc.

10.3.3 Primer

Primer for sealants shall only be as recommended by the sealant manufacturer, Primer shall have been tested for compatibility and durability with the sealant to be used and on samples of the surfaces to be selected.

10.3.4 Backdrop Material

Backdrop material shall be an expanded polyethylene of nominal density 35 kg/cum as recommended by the sealant manufacturer. It shall be of non-absorbent and non-staining material compatible with the sealant used. Tube or rod stock shall be rolled into the joint cavity.

10.3.5 Bond-preventive Materials

Bond-preventive materials shall be pressure-sensitive adhesive polyethylene tape or aluminium foil.

10.3.6 Equipment

The Contractor shall inter alia provide the following plant and equipment for the work.

T-paddle, follower plate, solid barrel gun, plastic nozzle, wire brush, heavy duty 500 rpm electric drill, palette knife, masking tape and paint brush for priming etc.

10.3.7 Working Life

Care shall be taken to ensure that material with adequate shelf life is provided. Material whose shelf life is over shall not be used in the works and shall be removed from the site forthwith. Depending on the storage, temperature and humidity, only one unit shall be drawn from the storage.

10.3.8 Curing Period

No portion of the work where sealant has been applied shall be allowed to be submerged or be wetted by any liquid for a period of 7 days after application of the sealant. This period may be modified depending on the temperature and humidity prevalent at the time.

10.3.9 Environmental Requirements

The ambient temperature shall be within the limits as given by the manufacturer, when the sealants are applied. The work shall not be carried out in a dusty atmosphere or when it is raining or when the humidity is high.

Sealants shall not be applied when the ambient temperature is below 4 degree C. When the ambient temperature is below 10 degree C but greater than 4 degree C, the sealant containers shall be stored for some hours at 21 degree C, to ease mixing and application.

10.3.10 Delivery and Storage

Materials shall be delivered to the job site in the manufacturer's original unopened containers.

The containers shall include the following information on the label:

- i) Name of supplier,
- ii) Name of material,
- iii) Formula,
- iv) Lot number,
- v) Colour
- vi) Date of manufacture,
- vii) Mixing instructions
- viii) Shelf life and
- ix) Curing time

Materials shall be carefully handled and stored to prevent contamination of foreign materials to exposure to temperatures exceeding 35 degree C.

10.4 Joints

The effective width to depth ratio shall be as per the table given below unless directed otherwise by the Engineer.

Table for Joint Dimensions

Surfaces	Joint Width	Joint Depth	
		Minimum	Maximum
For concrete masonry or stone:	6 mm	6 mm	6 mm
	Over 6 mm upto 12 mm	6 mm	Equal to width
	Over 12 mm	½ of width	½ of width

10.4.1 Surface Preparation

General

The surface of joints to be sealed shall be clean, dry, sound and free of all release agents, water repellents, laitance, oil, grease, dirt, chalk, particles of mortar, dust, loose rust, loose mill scale and other foreign substances. Oil and grease shall be removed with solvent and the surfaces shall be wiped with clean clothes.

10.4.2 Concrete and Masonry Surfaces

Where surfaces have been treated with curing compounds, oil or other such materials, the materials shall be removed by sandblasting or wire brushing. Laitance, efflorescence and loose mortar shall be removed from the joint cavity. The surfaces/edges shall be repaired with epoxy mortar to give smooth and even surfaces to correct lines and levels with a uniform gap for the length to be sealed.

10.4.3 Application

Masking Tape

Masking tape shall be placed on the finished surface on one or both sides of a joint cavity to protect adjacent finished surfaces from primer or compound smears. The masking tape shall be removed within 10 minutes after the joint shall be filled and tolled.

10.4.4 Bond-preventive materials

Bond-preventive materials shall be installed on the bottom of the joint cavity and other surfaces to prevent the sealant from adhering to the surfaces covered by the bond-preventive materials. The materials shall be carefully applied to avoid contamination of adjoining surfaces or breaking bond with surfaces other than those covered by the bond-preventive materials.

10.4.5 Backstops

The back or bottom of joints constructed deeper than specified shall be packed tightly with an approved backstop material to provide a joint of the depth specified.

10.4.6 Primer

The primer shall be used in accordance with the manufacturer's instructions. The primer shall be applied to the joint surfaces to be sealed only and not spill over or be applied to surfaces adjacent to the joints.

10.4.7 Application of Sealant

The sealant shall be gun-applied with a nozzle of proper size to fit the width of the joint indicated and shall be forced into grooves with sufficient pressure to expel air and fill the groove solidly. The sealant shall be uniformly smooth and free of wrinkles.

The plastic nozzles shall be inserted on the gun and cut to appropriate size. The sealant shall be gunned into joints using an even trigger pressure. The nozzle shall be cleaned occasionally.

The sealant shall be pressed into joints with a wet spatula and tooled within five minutes of application. The jointly shall be tooled slightly concave after the sealant is installed. The tolled joint shall present a smooth and professional joint giving the desired finish and shape. The masking tape shall be removed immediately after tooling.

Application equipment shall be cleaned with a tool cleaner, recommended by the manufacturer, after wearing PVC or rubber gloves and whilst the sealant is still in an uncured state.

10.4.8 Cleaning

The surfaces adjoining the sealed joints shall be cleaned of smears and other soiling resulting from the sealing application as the work progresses. Sealant adhering to, porous surfaces shall be left until is just cured and then removed by abrasion or other mechanical means.

10.4.9 Measurement

Measurement shall be made in running metres correct to two decimal places.

10.5 Water bars / Water stops

Where water bars/ water stops are shown on the drawings, the joints shall incorporate PVC water bar/ water stop such as "Fixostop" or approved equivalent (conforming to IS:12200). The water bars/ water stops shall be complete with all the necessary moulded or prefabricated intersection pieces assembled with bends and butt joints in running lengths made by welding in an electrically heated jig. The fabrication drawing made by the manufacturer shall be submitted by the Contractor for approval of the Engineer

Jointing and fixing of waterbars / waterstops shall be carried out strictly in accordance with the manufacturer's instructions which should be enumerated in a detailed method statement and submitted for approval / comments of the Engineer. The following types of waterbars / waterstops are proposed to be used in the Work.

- (a) 'FIXOSTOP' Type 230 KD or equivalent – To be used at construction joint in base slab
- (b) 'FIXOSTOP' Type 230 KV or equivalent – To be used at expansion joint in base slab
- (c) 'FIXOSTOP' Type 240 RS or equivalent – To be used at construction joint in between wall and base slab
- (d) 'FIXOSTOP' Type 240 H or equivalent – To be used at expansion joint in base slab

Water bars / water stops shall be of approved and appropriate type obtained from approved manufacturers.

The water bars / water stops shall be installed so that they are securely held in their correct position during the placing and compacting of the concrete. Necessary supporting devices to prevent sagging of the water bars / water stops shall be provided.

Where reinforcement is present adjacent to water bars / water stops, adequate clearance shall be left between the reinforcement and water bars / water stops to facilitate compaction of the concrete.

Double headed nails may be used in the edge of the water bar / water stop outside the line of the external grooves for fixing purposes, but no other holes shall be permitted through the water bar / water stop.

A representative of the manufacturer shall be present at site during the operations of installing, jointing and embedment of water bar / water stop. He shall monitor and certify that the work is being carried out strictly as per specifications and recommended practices.

Water bars / Water stops shall be measured and paid for separately as per BOQ.

10.5.1 MEASUREMENT

Water bars / Water stops shall be measured in running meters along the line they are to be laid. Laps and welding etc. shall not be measured separately. The length shall be taken in metres correct to two decimal places.

All wastages, laps and variations are deemed inclusive in the item rate quoted by the contractor and nothing extra is admissible on this account. Payment will be made only for the measured quantity incorporated in the work.

10.5.2 RATE

The rate quoted shall include the cost of materials all transportation etc. and labour involved in all the operations described above.

10.6 Compression Seal expansion Joint

Expansion joint type described here-after is the "Compression seal" type, but alternate designs can be proposed for approval of the Engineer (e.g. elastomeric omega-shape cover joint, or any other suitable joint type.)

- 10.6.1 Compression seal joint shall consist of steel armoured nosing at two edges of the joint gap suitably anchored to the deck concrete and a preformed chloroprene elastomers or closed cell foam joint sealer compressed and fixed into the joint gap with special adhesive binder.

10.6.2 Material

- 10.6.2.1 Steel Nosing: The steel nosing shall be of angle section ISA 100 x 100 conforming to weldable structural steel as per IS:2062. The thickness of legs shall not be less than 12mm. The top face of the angle shall be provided with Bleeder holes of 12mm diameter spaced at maximum 100mm centre so as to ensure that there are no voids in the concrete beneath the angle.

- 10.6.2.2 Anchorage: The anchorage steel shall conform to IS:2062 or equivalent. The steel nosing shall be anchored to the deck by reinforcing bars or anchor plates cast in concrete or a combination of anchor plates and reinforcing bars, anchor plates and anchor loops. This shall be achieved by passing transverse bars through the loops or plates.

The minimum thickness of anchor plates shall be 12mm. Total cross sectional area of bars on each side of the joint shall not be less than 1600sq mm per m length of the joint and the centre to centre spacing shall not exceed 250mm. The ultimate resistance of each anchorage shall not be less than 600 KN/m in any direction.

Corrosion Protection: All steel section shall be protected against corrosion by hot dip galvanising or any other approved anticorrosive coating with a minimum thickness of 100 micron.

10.6.2.3 Joint Seal

The sealing element shall be a preformed continuous chloroprene or closed cell foam seal with high tear strength, insensitive to soil, gasoline and ozone. It shall have high resistance to ageing and ensure water tightness. The seal should be vulcanised in a single operation for the full length of the joint required for carriageway, kerbs and footpaths, if any. The seal shall cater for a horizontal movement up to 40mm and vertical movement of 3mm.

The physical properties of chloroprene/closed cell foam sealing element shall conform to the following:

(a) Chloroprene Seal

It shall be preformed extruded multi-web cellular section of chloroprene of such a shape as to promote self removal of foreign material during normal service operations. Chloroprene of joint seal shall conform to clause 915.1 of IRC:83 (Part-II) and satisfy the properties stipulated in Table 1 herein above strip seal element specifications of these specifications except in respect of the working movement range of the sealing element which shall be as specified in CI G.2.4.1 above.

(b) Closed Cell Foam seal:

It shall be of preformed non-extruded non cellular section made from low density closed cell, cross linked ethylene vinyl acetate, polyethylene copolymer that is physically brown using nitrogen. The material shall possess properties as indicated in the Table 2 below.

Table-2
Properties of Closed Cell Foam Seal

Property	Special Value
(I) Density	41.7 – 51.3 kg/cum
(ii) Compression set on 25mm	50% compression samples (ASTM D 3575) for 22 hours at 23° C, 2 hour recovery; 13% set.
(iii) Working temperature	-70 to +70°C.
(iv) Water Temperature absorptions (total Immersion for 3 months) (ASTM3575)	0.09766 kg/sqm
(vi) Tensile strength	0.8 Mpa
(vii) elongation at break (ASTM D 3575)	195 +/-20%

- 10.6.2.4 Lubricant cum Adhesive: The type and application of material used in bonding the preformed joint seal to the steel nosing and concrete shall be as recommended by the manufacturer / supplier of the seal system.

10.6.3 Handling and Storage

- (i) The expansion joint material shall be handled with care and stored under cover.
 - (ii) All joint materials and assemblies shall be protected from damage and assemblies shall be supported to maintain true shape and alignment during transportation and storage.
- 10.6.4 Installation
- 10.6.4.1 The expansion joint shall be installed by the manufacturer / supplier or their authorised representative, who will ensure compliance of specified installation procedure and instructions.
- 10.6.4.2 The dimension of the joint recess and the width of the gap shall conform to the approved drawing.
- 10.6.4.3 Anchoring steel shall be welded to the main reinforcement in the deck maintaining the level and alignment of the joint.
- 10.6.4.4 Concreting of pocket/recess shall be done with great care using proper mix conforming to same grade as that of the deck concrete but no less than M30 grade in any case. The water-cement ratio shall not be more than 0.40. If needed, suitable admixtures may be used to achieve the workability. The width of pocket shall not be less than 300mm on either side of the joint. Care shall also be taken to ensure efficient bonding between already cast/existing deck concrete and the concrete in the joint recess.
- 10.6.4.5 At the time of installation, joint shall be clean and dry and free from spalls and irregularities, which might impair a proper joint seal.
- 10.6.4.6 Concrete or metal surfaces shall be clean, free of rust, laitance, oils, dirt, dust or other deleterious materials.
- 10.6.4.7 The lubricant cum adhesive shall be applied to both faces of the joint and joint seal prior to installation in accordance with the manufacturer's instructions.
- 10.6.4.8 The joint seal shall be compressed to the specified thickness for the rated joint opening and ambient temperature at the time of installation, which shall be between +05 to +35 degree C.
- 10.6.4.9 The joint seal shall be installed without damage to the seal. Loose fitting or open joints shall not be permitted.
- 10.6.5 Acceptance Criteria
- 10.6.5.1 All steel elements shall be furnished with corrosion protection system.
- 10.6.5.2 For the joint seal the acceptance test shall conform to the requirements stipulated in para above. The manufacturer/supplier of this type of joint shall produce a test certificate to this effect conducted in a recognized laboratory in India having NABL certification or abroad.
- 10.6.5.3 Prior to acceptance 25% of the completed and installed joints, subject to a minimum of one joint, shall be subjected to water tightness test. Water shall be continuously ponded along the entire length for a minimum period of 4 hours for a depth of 25mm above the highest point of deck. The width of ponding shall be at-least 50mm beyond the anchorage block of the joint on either side. The depth of water shall not fall below 25mm any time during the test. A close inspection of the underside of the joint shall not reveal any leakage.
- 10.6.6 Tests and Standards of Acceptance:
- The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria. The manufacturer/supplier shall furnish the requisite certificates from the recognised testing laboratory of India having NABL certification or abroad.
- The work shall conform to these specifications and shall meet the prescribed standards of acceptance.
- 10.6.7 Mode of Measurement
- The measurement for expansion joints as a finished work shall be in running meters nearest to a

centimetre.

10.6.8 Rates

The contract unit rate shall include the cost of all materials (including cast-in-situ concrete), labour, equipments, cost of transportation (overseas as well as with in country), cost of testing including cost of test samples and other incidental charges for fixing the joints complete in all respects as per specifications. However the cost of covering plate over shear keys will be measured in MT and paid separately.

10.7 Railings

10.7.1 General

Prefabricated railing as per approved drawings & details shall be erected at site and shall extend all along the full length of the viaduct and as shown in drawing. Fixing arrangements with deck shall be incorporated as per approved design & drawings.

Railing on viaduct shall not be constructed until the centering / supporting arrangement form work / supporting arrangement for the span has been released and the span is self supporting. For concrete and steel, specifications of the items of controlled concrete and reinforcement mentioned under relevant specifications shall be applicable.

Railing shall be carefully erected true to line and grade. Posts shall be vertical with a tolerance not exceeding 6 mm in 3 m. The pockets / blackouts left for posts shall be filled up with non-shrinkable mortar.

All edges and corners shall be straight and finished to true line and level. Forms shall either be of single width boards / plates or shall be lined with suitable materials duly approved by Engineer. Form joints in plain surface will not be permitted. All mouldings, panel work and level strips shall be constructed according to the details shown in the drawings.

10.7.2 Metal Railings

10.7.2.1 General

All complete steel / aluminium railing elements, terminal sections, posts, and other fittings shall be of shape, size and designation of approved material and make as given in the item of work or as directed by Engineer. In case of steel railing all these elements shall be galvanised or painted with an approved paint. If galvanised, all elements of the railings shall be free from abrasions, rough or sharp edges, and shall not be kinked, twisted or bent. If straightening is necessary, it shall be done by methods approved by Engineer.

Aluminium sections shall be of approved quality and make and free from scratches, stains and discoloration.

The Contractor shall take every precaution against damage of the components during fixing in position.

Damaged galvanized surfaces shall be cleaned and re galvanised. Special care shall be taken to prevent staining of all products, rust, mortar, etc. before it is put into use.

10.7.2.2 Fixing

The railing shall be carefully adjusted prior to fixing in place to ensure proper matching at abutting joints, correct alignment and camber throughout their length.

Fixing shall be strictly as per fixing details shown in the drawings or as directed by Engineer.

If sections are not galvanised, railing shall be given one shop coat of paint, and three coats of paint after erection.

All necessary holes, chases, etc., required in fixing shall be made by the contractor and made good after installation, without any extra charge.

10.7.3 Cast-In-Situ Railings

- 10.7.3.1 The portion of the cement concrete railing or parapet which is to be cast in place shall be constructed in accordance with the requirements for Cement Concrete described in the respective section of RCC. Forms shall either be of single width boards or shall be lined with suitable material duly approved by Engineer. Form joints in plane surfaces will not be permitted.

All mouldings, panel work and bevel strips shall be constructed according to details shown on drawings. All corners in the finished work shall be true, sharp and clean - cut and shall be free from cracks, spalls or other defects.

10.7.4 Precast Railings

Precast members for railings shall be of reinforced cement concrete to be constructed in accordance with the requirements of cement concrete described in respective sections of RCC and Pre-cast concrete. The precast members shall be removed from moulds as soon as practicable and shall be kept damp for a period of at least 14 days. During this period, they shall be protected from sun and wind. Any precast member that becomes chipped, marred, or cracked before or during the process of erection and fixing shall be rejected.

10.7.5 Measurements for Payment

Railings shall be measured as per BOQ as finished work.

10.7.6 Rate

Contract unit rate shall include cost of all labour, materials, tools and plant required for doing the work complete in all respects in accordance with above specifications and as shown in the drawings or as directed by Engineer.

10.8 Epoxy

Epoxy bonding agents for match cast joints shall be thermosetting 100 percent compositions that do not contain solvent or any non-reactive organic ingredient or pigments required for coloring. Epoxy bonding agents shall be of two components i.e., a resin and a hardener. The two components shall be distinctly pigmented. So mixing produces a third color similar to the concrete in the segments to be joined, shall be packaged in proportioned, labeled, ready-to-use containers.

Epoxy bonding agents shall be formulated to provide application temperature range that will permit erection of match cast segments at substrate temperature from 5° C to 40° C. depending upon the ambient temperature range, the following types of epoxy are recommended for use:

- 5° to 20° C : Fast reacting
- 15° to 30° C : Medium fast reacting
- 25° to 40° C : Slow reacting

If two surfaces to be bonded have different substrate temperatures, the adhesive applicable at the lower temperature shall be used.

Epoxy bonding agents shall be insensitive to damp conditions during application. After curing, shall exhibit high bonding strength to cured concrete, good water resistivity, low creep characteristics and tensile strength greater than concrete. In addition, the epoxy bonding agents shall function as a lubricant during the joining of match cast segments, as a filler to accurately match the surface of the segments and act as a durable water tight bond at the joint.

Epoxy bonding agents shall be tested to determine their workability get time, open time, bond and compressive strength and working temperature range. The frequency of the tests shall be as stated in the Technical Specifications of the Contract.

The contractor shall furnish the Engineer with samples of the material for quality assurance testing and a certification from a reputed independent laboratory having NABL. Certification indicating that the material has passes the required tests.

Specific properties of epoxy and the test procedures to be used to measure these properties shall conform to FIP requirement.

10.8.1 Mixing and Installation of Epoxy

Instructions furnished by the supplier for the safe storage, mixing and handling of the epoxy bonding agent shall be followed. The epoxy shall be thoroughly mixed until it is of uniform color. Use of a proper sized mechanical mixer operating at no more than 600 RPM will be required. Contents of damaged or previously opened containers shall not be used. Surfaces to which the epoxy material is to be applied shall be at least at 40°F and shall be free from oil, laitance form, release agent or any other material that would prevent epoxy from bonding to the concrete surface. All laitance and other contaminants shall be preferably removed by water rinsing, or, alternatively, by light sand-blasting. Wet surfaces shall be dried before applying epoxy bonding agents. The surface shall be at least the equivalent of saturated surface dry (no visible water).

Mixing shall not start until the segment is prepared for installation. Application of the epoxy bonding agent shall be according to the manufacturer's instructions using trowel rubber glove or brush on one or both surfaces to be joined. The coating shall be smooth and uniform and shall cover the entire surface with a minimum thickness of 1.5 mm applied on both surfaces and 3 mm if applied on one surface. Epoxy should not be placed within 10 mm of prestressing ducts to minimize flow into ducts. A discernible bead line must be observed in all exposed contact areas after temporary post-tensioning. Erection operations shall be coordinated and conducted so as to complete the operations of applying the epoxy bonding agent to the segments, erection, assembling and temporary post-tensioning of the newly joined segment within 70% of the open time period of the bonding agent.

The epoxy material shall be applied to all surfaces to be joined within first half of the get time as shown on the containers. The segments shall be joined within 45 minutes after the application of the first epoxy material placed and a minimum required temporary prestress over the cross section should be applied within 70 percent of the open time of epoxy material. The joint shall be checked immediately after the erection to verify uniform joint width and proper fit. Excess epoxy from the joint shall be removed where accessible. All tendon ducts shall be swabbed immediately after stressing while the epoxy is still in the non-gelled condition to remove or smooth out any epoxy in the conduit and to seal any pockets or air bubble holes that have formed that joint.

If jointing is not completed with 70 percent of the open time, the operation shall be terminated and the epoxy bonding agent shall be completely removed to the maximum possible extent from the surfaces. The surface must be prepared again and fresh epoxy shall be applied to the surface before resuming joining operations. As general instructions cannot cover all situations, specific recommendations and instructions shall be obtained in each case from the Engineer.

Completed segment tolerance for segmental Box girder viaduct / bridge construction

Finished segment tolerances should not exceed the following:

Length of match-cast segment (not cumulative).....	+ 5 mm
Overall height	+ 5 mm
Length of totally assembled span	+ 10 mm
Web Thickness.....	+ 5 mm
Depth of bottom slab.....	+ 5 mm

Depth of top flange.....	+ 5 mm
Overall top flange width.....	+ 5 mm
Top flange width (transverse position on track side).....	+ 5 mm
Diaphragm thickness.....	+ 5 mm
Grade of form edge and soffit.....	± 1.0 mm
Tendon hole location.....	± 3 mm
Position of shear keys.....	± 5 mm

Tolerance for erection of the span

Horizontal and vertical positions of the at-pier-segment shall be within 15 mm of the longitudinal alignment and grade.

10.9 SHEAR KEY DEVICES

General Description of the system

General

The shear Key is made of concrete cast in place in second pour after concrete decks are assembled. The shear keys shall take all horizontal loads (longitudinal and transverse). It is equipped with a system of fixation with high strength bars to one end of the deck, and with five vertical bearing taking the transverse horizontal loads and rotations.

Description of the proposed system

The system of fixation of the shear key to the deck is performed by high strength tensile bars installed on only one horizontal layer.

The system shall satisfy the following two main requirements.

- construction easiness
- maintenance easiness

The high strength tensile bars shall have good resilience and good resistance to fatigue as due to the rotation of the braking/acceleration loads, the bars are almost continuously loaded.

Material Characteristics

High tensile bars

Quality of steel: The quality of the raw material steel be according to the DIN EN 10083-1 equivalent. The chemical composition shall be such as to guarantee the following mechanical characteristics:

- Yield stress $F_y > 1050$ MPa
- Tensile stress $F_u > 1200$ MPa
- Elongation at breaking $> 10\%$
- Resilience at $20\%C > 50$ Joules:
-

The threading of the bars shall be made by rolling method (cold plastic deformation of the metal between two dies). The threads shall have a triangular profile H7 according to ISO 262-NFE 03053. The tolerance of the length of the bars is ± 5 mm

Due to the repetitive loading that will be applies to the bars, tests shall be carried out to demonstrate the fatigue resistance of the bars. The test criteria shall be as follows: _

- mean stress: $0.57F_y$
- stress range: ± 0.03
- 4million cycles
- after 4 million cycles, no breaking at less than $0.80F_y$

Other materials

The repartition plates shall be of S355 JO steel quality or equivalent, and each shall include an injection pipe.

The ends of the bars shall be equipped with a protection cap filled up with grease and fixed on repartition plate by threading.

The nuts at the ends of the bars shall be spherical in order to ensure that the tensioning is axial.

The sheaths shall be made of a 2mm-thick steel.

The injection product shall be wax in order to provide a good time –resistance and to provide flexibility under the deck rotations. The product shall be equivalent as for use for protecting stay cables or tension rods.

Elastomeric bearing system

On the movable side of deck, one sliding elastomeric bearing shall be installed longitudinally on each side or the shear key. The sliding elastomeric bearing shall be made of one laminated elastomeric pad and one sliding plate.

On the fixing side of deck, one laminated elastomeric bearing shall be installed longitudinally on each side of the shear key. In addition, at the interface between the shear key and one laminated elastomeric bearing, adequate recesses to allow for replacement without taking out the high tensile bars shall be installed transversally.

These elastomeric bearing shall be made of polychloroprene, and manufactured according to Euro norm EN 1337-3 or equivalent.

The sliding plate shall be PTFE, with elongation at break >300% and tensile strength from 29 to 40 MPa.

CORROSION PROTECTION**High tensile bars**

The protection against corrosion of the tensile bars shall be achieved by using wax injected in a steel tube. The bars will be protected against corrosion during transition and storage by sprayed oil or equivalent system.

Other materials

The upper repartition plate and the protection cap shall be sandblasted and shall receive 3 layers of coating.

The articulation room, the coupler and the lower ring shall be sandblasted and shall receive 3 layers of coating.

The articulation room and upper protection cap shall be filled up with grease.

TRANSPORTATION & STORAGE

The bars and the accessories shall be transported in wooden cases and in containers, or equivalent.

The bar threading shall be ring, or temporarily protected against shocks by greased tape and a steel ring, or equivalent. The protection of the threads shall be taken off just before the installation of the bars.

The bars and accessories shall be carefully stored at the job site under the following conditions:

- They should be protected from rain, and storage from room shall have ventilation.
- If the bars have be kept stored for long time, it will be necessary to ported them with a layer of solvable oil or equivalent in order to protect from them against corrosion.
- Before installation of the bars, if there is some corrosion, they shall be cleaned up as per the approved procedure. Acceptance of the bars shall be subject to approval of Engineer.

INSTALLATION PROCEDURE

The installation procedure is proposed as follows. Alternate methods can also be submitted by the contractors for approval of Engineer.

- 1- Shear key is poured before precast concrete deck segment are installed. The span must be assembled at a higher level to avoid conflicts with already built concrete key
- 2- Superstructure should have recess of 20mm for grouting by non-shrinkage grout at a later stage.
- 3- Erect the Superstructure on the temporary bearings/jacks with sliding surface at top at both ends.
- 4- Provide some arrangement to prevents deck sliding (E.g. under seismic load)

- 5- Move the girder by hand screwing /jacking bar by nearly 20mm.
- 6- At this stage vertical faced elastomeric pad is in position (resting on tubes)
- 7- Replace the temporary bearing with the permanent elastomeric bearing
- 8- Grout the gap between the girder (with hacked surface at grouting location) and the elastomeric bearing.
9. Bar stressing
10. Wax injection and capping

Note:

- a) The bars are installed after alignment check, and the bars are installed inside the spherical nut at movable end. Then the bars are pre stressed with jack. The bars are tensioned step by step (50% the other, then the remaining 50%)
- b) Injection is then made from the movable end, with heated wax through injection tube.

MAINTENANCE PROCEDURE

The system shall be such that it is possible to replace any device without any dismantling/ destruction of the concrete part of the structure.

The system shall be such that the maintenance procedure described below can be undertaken.

- a) Lateral elastomeric bearings
For the lateral vertical bearings, a theoretical gap of 2mm shall be provided on each side of the shear key. If it is needed to change one or all of these lateral bearings, then as the deck will not be in contact on each side at a time, the lateral bearings on the non-compressed side are taken out first. First the sliding plate is taken out, then the elastomeric bearing. Then the deck may need to be translated laterally to take out the elastomeric bearing on the compressed side. For this, steel angles can be split in the concrete support for jack or threaded bars. The needed force to distort the neoprene bearings supporting the deck will be calculated.
- b) Transversal elastomeric bearings
Due to opening on the bearing, it will only necessary to un-stress temporarily the tie-bars to take out the bearings and replace it
- c) Pre stressed tie-bars
Bars will be un-stressed, and taken out with the help of device provided at the movable end. The connection between the spherical nut and the protection cap will not allow the spherical nut to turn. The wax product will come out with the bar. New bars are introduced as per first installation, then tensioned and wax injection.

10.10 ROAD WORKS

The road work items will be executed as per the BOQ description and latest MORTH specification as directed by Engineer.

These Specifications contained herein shall be read in conjunction with other tender documents.

Generally the work shall be carried out as per the latest edition of "Specifications for Road and Bridge works" of Ministry of Road Transport & Highways (MORTH) as published by Indian Roads Congress (MORTH fifth revision published by the Ministry on 03-01-2013) and CPWD specifications - 1996/2002 with correction slips & amendments upto date to the extent they are applicable to the works covered under scope of works. However, the provision of MORTH specifications takes precedence over CPWD specifications. Further the specifications contained herein will supersede the provisions of the MORTH & CPWD specifications to the extent of their applicability.

The Work shall be carried out in accordance with the "Good for Construction" drawings and designs as would be issued to the Contractor by the Engineer duly signed and stamped by him.

10.11 Approved Materials/Makes/Manufacturers /Likely suppliers.

Approved Materials/Makes/Manufacturers/Likely suppliers are those who conform to the relevant Standard Specification, IS codes and other relevant codes etc. and shall be of approved by Employer/Engineer.

SECTION - S.11- STEEL BRIDGE GIRDER ERECTION

Fabrication and erection shall be as per Indian railway Bridge Codes , Specifications, IRS BS110-R and other referred specifications/standards therein (**as detailed in applicable Codes of Practice in this section**).

Ref clauses: 11.1.6. Materials, 11.1.7. Fabrication, 11.1.8. Trial Assembly, 11.1.9. Metallizing and painting, 11.1.10 Transportation to site, Stacking, Final Assembly and Erection at site.

11.1 Structural Steel Erection Work - General

11.1.1. Scope of Specification

This specification covers the scope of work for structural steel erection works, submittals by the Contractor, applicable codes of practice and the specifications for the materials to be used, including steel, bolts and nuts, washers etc. and the storage thereof.

11.1.2. Scope of Work`

The scope of work for the contractor in respect of structural steel erection work shall cover, but shall not be limited to the following:

Preparation of complete erection sequence drawing based on the suggested erection scheme(s) as proposed by contractor, required for all the permanent and temporary structures including launching nose / truss.

Submission by the contractor, for examination by the Engineer, detailed particulars of the proposed method of erection of the superstructure steelwork, together with complete calculations relating to strength and deflection. If the erection scheme necessitates the strengthening of the permanent steel work, the contractor shall submit, for approval of the Engineer, the methods he proposes for making good the permanent steelwork after removing the temporary work. The contractor shall also submit the design and fabrication drawings incl. detailed calculations of launching nose / truss, counterweight, all temporary supports, staging, bracings etc. required for safe erection, for approval of the Engineer.

Providing all construction and transport equipment, tools, tackle and consumables, materials, labour and supervision required for the erection of the structural steelwork.

Receiving, unloading, checking and moving to storage yard / storage, guarding and upkeep of fabricated steelwork and other consumable materials and fasteners at site.

Compiling and furnishing detailed bill of materials of fabricated parts received from the fabricator.

Loading, Transportation and unloading of all fabricated structural steel materials from storage yard to erection site, handling, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location, according to approved erection drawings and / or as directed by the Engineer.

Setting out, aligning, keeping in plumb, bolting, welding and securely fixing the fabricated steel structures in accordance with the erection scheme, or as directed by the Engineer.

Requisite, site planning to all fabricated steelwork, as per requirements of related specification of the painting.

Carrying out all major modifications of the fabricated steel structures, as directed by the Engineer, including but not limited to the following:

Removal of bends, kinks, twists etc. for parts damaged during transport and handling. Cutting, chipping, filing, grinding etc. as required or preparation and finishing of site connections.

Drilling of holes which are either not drilled at all or are wrongly drilled.

11.1.3 Submittals

- A. On commencement of the Project, the Contractor shall submit the following:
- i) Prior to the technical submittals, the contractor shall submit the proposed overall schedule for documentation such as calculations, erection drawings, shop / working drawings for all temporary structures etc. It is highlighted that structural steel member dimensions indicated in tender drawings are tentative only, and may be modified during final design stage.
 - ii) A detailed list of all constructional Plant & Equipment, such as cranes, derricks, winches, welding sets, erection tools etc. their make, model, present condition and location, available to the contractor and the ones he will employ on the job to maintain the progress of work in accordance with the contract.
 - iii) The total number of experienced personnel of each category, like fillers, welders, riggers etc., which he intends to deploy on the work.
- B. The contractor shall submit a detailed erection programme for completion of the work in time and in accordance with contract. This will show, in a Proforma approved by the Engineer, the target programme, with details of erection proposed to be carried out in each week, details of major equipment required and an assessment of required strength of various categories of workers.
- C. The contractor shall submit complete design calculations for any alternatives sections (for permanent structure) proposed by him, for approval of the Engineer. Use of any alternative section shall be subjected to approval of the Engineer. However, no escalation in unit rates of work shall be allowed for such cases.

11.1.4. Furnishing of information

- A. Design drawings shall be furnished to the contractor and all such drawings shall form part of these Specifications.
- B. The Engineer reserves the right to make changes in the design drawings even after release for preparation of shop drawings to reflect addition, omission & modifications in data / details and requirements. Contractor shall consider such changes as part of these Specifications and the contract, and no claims shall be entertained on this account.
- C. Design drawings, approved by the Engineer, will show as appropriate the salient dimensions, design loads, sizes of members, location of openings at various levels and other necessary information required for the preparation of fabrication drawings, designs and erection details.

D. It shall be clearly understood that the drawings of the Engineer are design drawings. The typical details of connection, cuts, notches, bend etc where shown in the design drawings are only for general guidance of the contractor. The contractor shall design and develop all such details based on the design forces and functional requirements.

E. In case of variations between design drawings and specifications, the decision of the Engineer shall be final. Should the contractor, find any discrepancy in the information furnished by the Engineer, same shall be immediately brought to the notice of Engineer for resolution. The contractor shall obtain clarifications on discrepancies from Engineer before proceeding with the work.

F. No detailed erection or shop drawings for temporary structures will be accepted for examination by the Engineer unless the same, have first been completely checked by the contractor's qualified structural engineer (independent agency to be appointed by contractor) and are accompanied by an erection plan showing the location of all pieces detailed. The contractor shall check and ensure that detailing of connections is carefully planned to obtain ease in erection of structures, including field-welded connections and / or bolting.

G. No fabrication work shall be started by the contractor without prior approval of Engineer on the relevant drawings. Approval by the Engineer of any of the drawings shall not relieve the contractor of his responsibility to provide correct design of connections, workmanships, fit of parts, details, materials and errors or omissions of all work shown thereon. The approval of Engineer shall constitute approval of the size of members, dimensions and general arrangement, but shall not constitute approval of the connections between members and other details.

H. Drawings, for approval, shall be submitted by the contractor in an orderly manner commensurate with erection sequence and approved construction programme.

I. The contractor shall furnish ten prints of all approved final drawings including soft cop in CD ROM for interface / field use and record purpose.

J. The drawings prepared by the Contractor, and all subsequent revisions thereof shall be at the cost of the Contractor, and no separate payments shall be made for the same. Revisions shall incorporate all modifications, field changes, substitutions etc. effected. The rates / prices quoted for fabrication work shall be deemed to include the cost of such drawing work.

K. All the drawings shall be prepared in metric units. The drawings should preferably be of A-1 standard size, and the details shown therein shall be clear and legible. These drawings shall include but shall not be limited to the following:

- i) Assembly drawings, giving exact sizes of the sections to be used and identification marks of the various sections.
- ii) Shop details of temporary structures together with detailed calculations.
- iii) Detailed shop drawings for proper co-ordination with the concrete components to which the steel members shall be connected, as required.
- iv) Any other drawings or calculations that may be required for proper completion of the works and clarification of the works of substituted parts thereof.
- v) All 'as-built' drawings.

11.1.5. Applicable Codes of Practice (Latest Revision)

The following specifications, standards and codes are included as part of this Specification. All Standards, specifications, codes of practice current on the date of signing of agreement and referred to herein shall be applicable.

INDIAN RAILWAY SPECIFICATIONS	INDIAN RAILWAY STANDARD SPECIFICATION FOR FABRICATION AND ERECTION OF STEEL GIRDER BRIDGES AND LOCOMOTIVE TURN-TABLES (FABRICATION SPECIFICATION) SERIAL NO. B1-2001 with latest correction slips
INDIAN RAILWAY CODE	Indian Railway Standard Code of Practices for metal arc welding for structural steel bridges carrying rail cum road or pedestrian traffic (Adopted 1972 Revised 2001) with latest correction slips.
INDIAN RAILWAY CODE	INDIAN RAILWAY STANDARD CODE OF PRACTICE FOR THE DESIGN OF STEEL OR WROUGHT IRON BRIDGES CARRYING RAIL, ROAD OR PEDESTRIAN TRAFFIC (Steel Bridge Code) with latest correction slips
INDIAN RAILWAY RDSO GUIDELINES	GUIDELINES ON FABRICATION OF STEEL GIRDERS FOR CONSTRUCTION/FIELD ENGINEERS BS –110 (R) (With upto date Addendum & Corrigendum) ISSUED BY B&S DIRECTORATE RESEARCH DESIGNS AND STANDARDS ORGANISATION LUCKNOW-226011.
IS:800 (2007) RA2017	Code of Practice for General Construction in Steel.
IS:808 (2021)	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle sections.
IS:800 (2007) (RA2017)	Covered Electrodes for Manual Metal Arc Welding of Carbon & Carbon - Manganese Steel.
IS:816 (1969) (RA2019)	Code of Practice for Use of Metal Arc welding for General Construction in Mild Steel.
IS:817 (1966) (RA2019)	Code of Practice for Training and Testing of Metal Arc Welders.
IS:919 (2014) (RA2019)	ISO System of Limits & Fits (Part 1 & Part 2)

IS:1148 (2009) (RA2021)	Hot Rolled Rivet Bars (up to 40 mm) for Structural Purposes.
IS:1182 (1983) (RA2020)	Recommended Practice for Radio Graphic Examination of Fusion Welded Butt joints in steel plates.
IS:1363 (2023)	Hexagon Head Bolts, Screws and Nuts of Product Grade C. (Part 1 to Part 3)
IS:1364 (Latest revisions)	Hexagon Head Bolts, Screws and Nuts of Product grade A & B. (Part 1 to Part 5)
IS:1367 (Latest revisions)	Technical Supply Conditions for Threaded Steel Fasteners.
IS:1852 (1985) (RA2022)	Rolling & Cutting Tolerances for Hot-Rolled Steel Product
IS:2016 (1967) (RA2021)	Plain Washers
IS:2062 (2011) RA2021	Steel for General Structural Purposes.
IS: 2595 (2008) RA2008	Code of Practice for Radio Graphic Testing.
IS: 3600 (Latest revisions)	Methods of Testing Fusion Welding joints (Part 1 to Part 9)
IS: 3658 (1999) RA2020	Code of practice for Liquid Penetrant Flow, Detection.
IS:4000(1992) RA2017	High Strength Bolts in Steel Structures Code of Practice.
IS:4353(1995) RA2021	Recommendations for Submerged Arc Welding of Mild Steel and Low Alloy Steel.
IS:4943(1968) RA2019	Recommendations for Submerged Arc Welding of Mild Steel and Low Alloy Steel
IS: 5334 (2014) RA2020	Code of Practice for Magnetic Particle Flow Detection of Welds.
IS: 5369 (1975) RA2021	General requirements for Plain Washers and Lock Washers.
IS: 5372 (1975) RA2021	Taper Washers for Channels.
IS: 5374 (1975) RA2021	Taper Washers for I Beams
IS: 6623 (2004) RA2021	Specifications for High Strength Structural nuts.
IS: 6649 (1985) RA2021	Specifications for hardening and tempering washers for high strength structural nuts.
IS: 6755 (1980) RA2021	Double Coil Helical Spring Washers
IS: 7215 (1974) RA2021	Tolerances for Fabrication of Steel Structure.
IS: 7318 (1974) RA2023	Approval Test for Welders when welding procedure approval is (Part I) not required - fusion welding of steel.
IS: 8910 (1978) RA2022	General requirements of Supply of Weldable Structural Steel.

IS: 9595 (1996) RA2019	Recommendations for Metal Arc Welding of Carbon & Carbon - Manganese Steels.
------------------------	--

IR bridge code, specifications, manual, RDSO Specifications and guide lines shall be referred for compliance.

11.1.6. Materials

11.1.6.(a) Steel Plates, Structural Section:

High tensile steel shall comply in all respects with the requirement of IS:2062-2011(RA2021) (latest version).

Grade of steel for composite steel girders shall be of Grade E450 BR/E350 B0 conforming to IS: 2062-2011. Grade of steel for the rolled section Shall conform to E250/any other Grades as per the GFC Drawings and as approved by the Engineer.

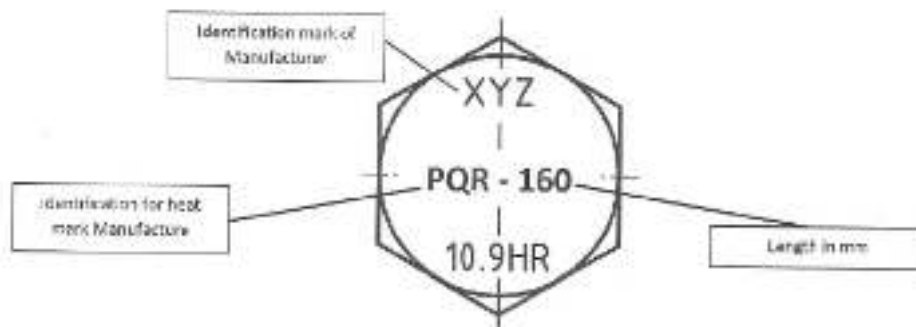
11.1.6.(b) Bolts:

High strength Friction grip bolts shall be used as specified under clause 28.9 of IRS B1 latest shall be followed.

For the purpose of HSFG connections, only high strength structural bolts confirming to the requirements for assemblies of high-strength structural bolts and nuts of system HR suitable for preloaded joints with large width across flats as specified in EN 14399-3 together with EN 14399-1 and 14399-2 shall be used. Specification for bolts and reference standards for material, general requirements, thread, mechanical properties, tolerances, finish-coatings, surface integrity, acceptability etc. has been given in Table 3 of EN 14399-3. EN 14399-3 gives two property classes: 8.8 or 10.9 for the same and bolts shall conform to IS 3757. The bolts have the following characteristics:

(a) Property class: A property class has two parts separated by a decimal in the form x.y. The first part, x, indicates 1/100 of the nominal tensile strength in Newton per sq mm and y indicates ten times the ratio of the lower yield stress and nominal tensile strength. For example, property class 8.8 means that the bolt will have nominal Ultimate Tensile strength of 800 N/mm², and lower yield stress of 80% of 800 N/mm², i.e. 640 N/mm².

(b) Identification/Marking: High strength structural bolts manufactured according to EN 14399-3 shall be marked with: (a) Property class marking with the letters HR e.g. 8.8HR or 10.9HR (b) Identification mark of the manufacturer of bolting assembly. It is permissible for the marking to be either embossed or indented on top surface of the head. For having better traceability, heat mark of the raw material shall be embossed on the bolt head. Heat mark may also be embossed on nut and washers if sufficient space for embossing heat mark is available on nuts and washers. Apart from heat mark, length of bolt shall be embossed on bolt head. This will be in addition to name of manufacture and property class of bolt material.



Typical Marking on bolt-heads

(c) Dimensions: Dimensions of bolts shall be as per Table 2 of EN14399-3. The bolt length shall be chosen such that after tightening the following requirements are met for bolt end protrusion beyond the nut face and the thread length: (a) The length of protrusion shall be at least the length of one thread pitch measured from outer face of the nut to the end of the bolt. (b) For preloaded bolts according to EN 14399-3, at least four full threads (in addition to the thread run out) shall remain clear between the bearing surface of the nut and the unthreaded part of the shank.

(d) Surface Finish & Coatings: Wherever property class 8.8 bolts are used these shall be hot dip galvanized as per ISO: 10684 (latest version) to provide salt spray resistance suitable as per site condition depending upon severity of environment. Property class 10.9 bolts shall not be hot dip galvanized since this may cause hydrogen embrittlement. So these bolts should be coated with Zinc flakes as per ISO: 10683 (latest version), to provide salt spray resistance suitable as per site condition depending upon severity of environment. However, depending on the site conditions, locations of the bolts in the structure and corrosion proneness, use of Zinc flake spray coating as per ISO 10683 (latest version) can be adopted even for property class 8.8 bolts as well.

11.1.6.(c) Nuts:

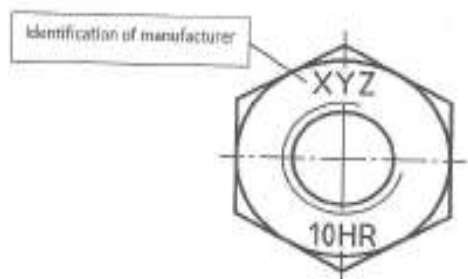
Nuts shall have following characteristics:

For the purpose of HSFG connections, only high strength structural nuts confirming to the requirements for assemblies of high-strength structural bolts and nuts of system HR suitable for preloaded joints with large width across flats as specified in EN 14399-3 together with EN 14399-1 and 14399-2 shall be used. Specification for nuts and reference standards for material, general requirements, thread, mechanical properties, tolerances, finish-coatings, surface integrity, acceptability etc. has been given in Table 5 of EN 14399-3. Nuts shall run freely on their partnering bolt, which is easily checked during hand assembly. Any nut and bolt assembly where nut does not run freely shall be discarded. If a power tool is used, either of the following two checks may be used: (a) For each new batch of nuts or bolts their compatibility may be checked by hand assembly before installation (b) For mounted bolt assemblies but prior to tightening, sample nuts may be checked for free running by hand after initial loosening. The nuts have the following characteristics:

(a) Property Class: Nuts are designated by property class designation, which is equal to 1/100 of the minimum tensile strength in Newton per square mm of the bolt. For HSFG bolting assemblies, the property classes to be used are 8 and 10 as specified in EN 14399-3. Property class 8 nut to be used with bolts of property class 8.8 only whereas property class 10

nuts can be used with bolts of property class 8.8 and 10.9 both. Dimensions of the nuts shall be as per the table 4 of EN 14399-3.

(b) Identification of Nut: High strength structural nuts manufactured according to EN 14399-3 shall be marked with: (a) Property class marking with the letters HR e.g. 8HR or 10HR (b) Identification mark of the manufacturer of bolting assembly. The marking shall be indented on either bearing face of chamfered nuts and shall be either indented or embossed on the non-bearing face of washer faced nuts.



Typical markings on nuts

(c) Surface finish and coatings of Nut: HSFG nuts of property class 8 shall be hot dip galvanized as per ISO 10684 (latest version) to provide salt spray resistance suitable as per site condition depending upon severity of environment. Property class 10 nuts shall not be hot dip galvanized since this may cause hydrogen embrittlement. So these nuts should be coated with Zinc flakes as per ISO: 10683, to provide salt spray resistance suitable as per site condition depending upon severity of environment. However, depending on the site conditions, locations of the nuts in the structure and corrosion proneness, use of Zinc flake spray coating can be adopted even for property class 8 nuts as well. In nuts the thread type depends on the type of coating adopted for nuts. In case of hot dip galvanization of nuts, the thread in nuts shall be as per tolerance class 6AZ as per ISO 261, ISO 965-5 and in other type of coatings the threads shall be as per tolerance class 6H as per ISO 261, ISO 965-2, ISO 965-5.

(d) Position of nut in bolt: HSFG bolt cannot be easily opened out except by use of torque wrench. Still, as an additional precaution, it may be ensured that the nut is not easily accessible for opening out by anti-social elements, the same shall be provided preferably as follows:

- In girder web: Towards outside of the girder.
- In flanges: Towards bottom (Except when in composite construction).
- In composite construction: Towards inside of concrete.
- In bracing: Towards the rolled section side so that the space for rotation of the nut is not readily available.
- Where Tapered washer is used, the nut shall preferably be on the other side.

11.1.6 (d) Shear connectors (Studs):

Shear connector shall conform to Report no. BS 115: RDSO Guidelines for composite construction including shear connectors and ISO13918:2017(E).

Studs shall be made from steel conforming to ISO-13918.

Chemical and Mechanical characteristics of finished stud material are as follows:

Symbol	Material/Material group/Property class	Standard	Mechanical properties of the finished stud
--------	--	----------	--

SD1	Material Group 1 with the limits $C < 0.2\%$, $CEV < 0.35$, $Al > 0.02\%$	ISO/TR 15608	$R_m > 450 \text{ N/mm}^2$ $ReH > 350 \text{ N/mm}^2$ $A_5 > 15\%$ Where, R_m is the tensile strength of steel, ReH is the upper yield of material and A_5 is the percentage elongation at fracture as per ISO 6892-1/ ISO13918
-----	---	--------------	--

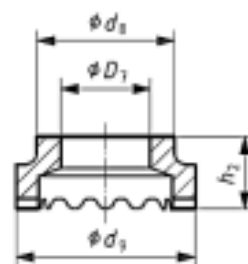
Welding of Stud:

Automatic stud welding process as mentioned IRS BS-115 shall be followed for stud connection with steel member.

The welding parameters and the welder shall be qualified.

Ceramic Ferrules for the studs shall be brought for welding the studs. The dimensions shall conform to the following:

Dimensions in millimetres				
Form	$D_1^{+0.5}_0$	$d_8 \pm 1$	$d_9 \pm 1$	$h_2 \approx$
UF 25	26,0	35,5	41	21
^a At the manufacturer's discretion.				



The dimensions of 5% welds shall be measured and verified against the required dimensions: Any stud with cumulative weld-defect length less than 10% of the circumference shall be considered acceptable and no action shall be taken.

Any stud with cumulative weld-defect length within 10% and 20% of the circumference shall be considered 'repairable' provided that clustering of such repaired studs does not exceed:

- 1 in 6 in end quarter span.
- 1 in 3 in middle half span.

If the defective weld clustering is more than above limits, the studs shall be considered 'not repairable'.

Any stud with cumulative weld-defect length more than 20% shall also be considered as 'defective and not repairable'.

Note: For fabrication of welded composite girders, shear connectors shall be welded on top flange plate prior to assembly of I-section. This facilitates correction of any distortion of flange plate developed during the welding of shear connectors. (IRS-B1)

Ring Test: 1 in 20 (5%) studs shall be tested by bend test. It involves striking the side of the head of the stud with a 2 Kg hammer. A ringing tone achieved after striking indicates good fusion whereas dull tone indicates a lack of fusion.

Bend Test: 1 in 100 (1%) studs shall be tested by bend test. The test consists of bending the studs after they are allowed to cool, to an angle of approximately 60° from their original axes by either striking the studs with a hammer on the unwelded end or placing a pipe or other suitable hollow device over the stud and manually or mechanically bending the stud.

The bending shall be done in the direction opposite to any arc blow or visual imperfection in the weld.

Visual Inspection, repair/rejection of member shall be as per guidelines in Clause 6.K of IRS BS 115

11.1.7. Fabrication:

Fabrication of steel structures shall be as per GFC drawings.

Below documents shall be obtained approval from Engineer before commencement of structural fabrication works:

Quality Assurance plan, Welding Procedure Specifications sheets (WPSS), Welding Procedure Qualification records (WPQR)

Use of approved raw materials, welding consumables, Engagement of Qualified welders and implementation of approved welding procedures shall be ensured in all stages of fabrication.

All steel materials, plates, bars and structural's shall have straight edges, flat surfaces and be free from twist. If necessary, they shall be cold straightened or flattened by pressure before being worked or assembled unless they are required to be of curvilinear form. Pressure applied for straightening or flattening shall be such as it would not injure the material and adjacent surfaces or edges shall be in close contact or at uniform distance throughout.

Flattening and straightening under hot condition shall not be carried out unless authorized and approved by the Engineer.

Plaining:

Except where otherwise indicated, cutting of all plates and sections shall be affected by shearing or sawing. All edges shall be clean, reasonably square and true. Wherever possible the edges shall be cut in a shearing machine, which will take the whole length of the plate in one cut. (IRS-B1)

Plaining or machining of the edges or surface shall be carried out when so specified in the contract drawings or where specifically ordered by the Engineer. Where machining is specified, the plates or all sections shall be cut in the first instance to such a size so as to permit not less than 3mm of metal being removed from each sheared edge or end, in the case of plates or sections of 12mm or less in thickness and not less than 6mm of metal being removed in the case of plates and sections exceeding 12mm in thickness. (IRS-B1)

Flame cutting by mechanically controlled torch/torches shall be accepted both in the case of mild steel and high tensile steelwork. Provided the edge as given by the torch is reasonably clean and straight, plates may be cut to shape and beams and other sections cut to length with a gas cutting torch, preferably oxyacetylene gas should be used. (IRS-B1)

While cutting the plates or other section the heat/cast mark should be transferred to all cut members while using these members for fabrication. Proper record of heat mark should be maintained/ correlating it with the components of girder. (IRS-BS-110)

Jigs and Templates:

Jigs:

Jigs and templates provided shall be as per GFC drawings.

Jigs of main members of the open web girders are fabricated on the camber length with the adoption of the field holes at nominal length layout through master gussets. (IRS-BS-110)

Jigs shall be checked from time to time for their wear and tear to maintain the accuracy during work. (IRS-BS-110)

Templates:

The templates throughout the work shall be of steel. The template shall be used for marking of cutting material and as well as profile machining for girders.

Templates shall be used for marking of drilling holes in steel structures other than girder of Railway loadings. (B1 – Clause 14)

Parts to be welded shall be assembled such that the joints are easily accessible and visible to the operator. Jigs and manipulators shall be used, where practicable, so that the welding can be carried out in the most suitable position. Jigs shall maintain the alignment with the minimum restraint so as to reduce the possibility of locked in-stress. (Welded bridge code)

Welding:

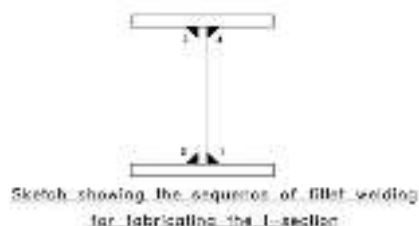
All welds should be done by submerged-arc welding process either fully automatic or semi-automatic. Carbon di oxide welding or manual metal-arc welding may be done only for welds of very short runs or of minor importance or where access of the locations of weld do not permit automatic or semi-automatic welding. (IRS-B1)

Site welding should not be undertaken except in special circumstances with the approval of the Engineer. Site welding should be confined to connections having low stresses, secondary members, bracings etc. (IRS-B1)

i. Connection of Flanges to Web:

The flanges of plate girders shall be connected to the web by Submerged Metal Arc_welding as per GFC Drawings.

The sequence of welding to be followed for fabrication of I Section shall be as below, (IRS-B1)



ii. Stiffeners:

Stiffeners provided shall be of required dimensions as per GFC Drawings.

Stiffeners shall not be joggled and shall be solidly packed throughout. (Steel Bridge code)

Intermediate stiffeners carrying cross bracings or diaphragms shall not be connected to the web by intermittent fillet welds and shall be located away from web splices. (Welded Bridge Code)

The size of normal fillet weld shall be taken as the minimum leg length. The size of a deep penetration fillet weld shall be taken as the minimum nominal leg length plus 2.4 mm.

The minimum size of the first run or of a single run fillet welds shall be as given in Table-

Table-I, Minimum size of first run of a fillet weld		Minimum fillet weld as given in to avoid the cracking in absence of
Thickness of thicker part	Minimum Size	
6 mm up to and including 20 mm	5 mm.	
Over 20 mm up to and including 32 mm	6 mm.	
Over 32 mm up to and including 50 mm	8 mm.	

I. size of shall be Table II risk of the pre-heating.

Table-II Minimum size of a fillet weld	
Thickness of thicker part	Minimum Size
Up to and including 6 mm	3 mm
Over 6 mm up to and including 12 mm	4 mm
Over 12 mm up to and including 18 mm	6 mm
Over 18 mm up to and including 36 mm	8 mm
Over 36 mm up to and including 56 mm	10 mm
Over 56 mm up to and including 150 mm	12 mm
Over 150 mm	16 mm

iii. Ends of weld:

The ends of joint shall be welded so as to provide the full throat thickness. This shall be done, in all cases of parent metal more than 20 mm thick and preferably in other cases also, by extending the ends of the welds past the edges of the parts joined by the use of run-on and run-off plates with a similar joint preparation and of reasonable thickness not less than the thickness of the part joined and of the length not less than 40 mm.

If run on and run off plates are removed after completion of the welds, the ends of the weld shall be finished smooth and flush with the edges of the abutting parts.

Inspection of Welding

All tests and requirements shall comply with approved drawings, WPSS and Inspection & Test Plan approved by the Engineer:

Visual Exam of Welds-Quality of weld, uniformity of weld bead, size of the weld, weld defects e.g. under cut, blow hole, porosity, spatter, crack etc. Should satisfy para 31 and Appendix C of Welded bridge code. (IRS-BS-110)

Metallographic and NDT Exam of Fillet Welds-Macro etching on girder, run-on, run-off tabs for ensuring proper weld quality, Dye penetrant examination etc., should be arranged by fabricator, for independent inspection. (IRS-BS-110)

- a. For Fillet Welds: Visual, D.P. Test, Fillet Size, Penetration, Leg Length, Throat thickness.
- b. For butt Welds RT/UT tests, as applicable by Visual, Gauge & Macro Etching. (IRS-BS-110, Annexure I, Sr. no. 4).

Bolting connections (HSFG):

Holes for HSFG Bolts: Normal holes in the steel members being connected by the rivets shall be used for HSFG bolts also, subject to the following:

- a) Making of holes: The holes shall be made by drilling only.
- b) Nominal Diameter of Hole: The nominal diameter of hole shall be 1.5 mm more than the bolt diameter for less than 25mm bolt and 2mm more than the nominal diameter of the HSFG bolt for larger diameters.
- c) Oversize Holes: In case the bolts are to be provided in existing structure, the maximum size of hole shall not exceed $1.25 d$ or $d + 4$ mm whichever is less. (28.10 – IRS-B1-A&C 6)

Surface preparation on steel at bolting locations:

The steel interface between the plies which form a joint having HSFG bolts shall have special surface preparation so that sufficient slip factor is available. The surface preparation shall be as assumed by designer in design, based on slip factor specified in Table XIII of Steel Bridge Code. (28.10.3 – IRS-B1 A&C 6)

The interface between the plies which are connected together by the HSFG bolts shall be “Aluminium metallised without any over coating”. (28.10.3 – IRS-B1 A&C 6)

11.1.8 Trial Assembly: (IRS-BS-110)

First span is always trial assembled to check whether fabrication process is proper or require any correction in jigs, workmanship or procedures to ensure regular quality output. Following important parameters are checked during trial assembly: -

a) Camber:

Camber shall be checked while the girder is supported on the nodal points on camber jacks and after releasing jacks i.e. for residual camber with girder resting on bearing ends. The camber measurements should be done with appropriate levelling instrument:

b) Dimensional check:

- i. Overall length
- ii. Bearing centres
- iii. Height
- iv. Truss center
- v. Center to center distance of rail bearers
- vi. Center to center distance of panel points
- vii. Squareness
- viii. Alignment of the girder
- ix. Fairing of holes
- x. Verticality
- xi. Infringement, if any
- xii. Butting of compression flange.

Component Inspection: (IRS-BS-110)

Detailed inspection of dismantled components of trial erected span is carried out to see the integrity of components. There should not be any elongation of holes, tearing of edges or other defects after dismantling of trial assembly.

11.1.9 Metallizing and Painting:

Surface preparation:

Prior to the application of protective coating, the surface of work shall be carefully prepared removing mill-scale, rust, etc. using wire brushes, sand or grit blasting as stipulated and approved by the Engineer.

Specifications under Appendix VII of IRS-B1 shall also be referred.

Metallizing:

For all components, the protective coating by metallizing with sprayed aluminium as specified in the Appendix VII of IRS-B1 shall be provided.

The chemical composition of aluminium to be sprayed shall be 99.5% aluminium conforming to IS:2590.

The nominal thickness of the coating shall be 150 μ (microns). (in 2 coats x 75 μ)

Painting as per painting schedule given below may be applied:

- (i) One coat of etch primer to IS:5666. (Thickness – 1 x 10 μ)
- (ii) One coat of zinc chrome primer to IS:104 with the additional proviso that zinc chrome to be used in the manufacture of primer shall conform to type 2 of IS:51. (Thickness: 1 x 30 μ)
- (iii) Two coats of aluminium paint to IS:2339 brushing or spraying as required. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second finishing coat shall be applied after touching up the primer and the finishing coat if damaged in transit. Appendix VII of IRS-B1 may also be referred in addition. (Thickness: 2 x 20 μ)

Dry Film Thickness shall be measured by Elco meter or any other approved method.

11.1.10 Transportation to site, Stacking, Final Assembly and Erection at site:

Detailed methodology describing necessary stages, schemes, documents etc., including safety and stability of the structure, shall be submitted to the Engineer for Approval prior to commencement of the works. Approval of Railway shall be taken (by contractor) wherever required as per the direction of Engineer with no extra cost.

11.1.11 Storage of Materials

11.1.11.1 General

All materials shall be so stored as to prevent deterioration, and to ensure the preservation of their quality and fitness for the work. If required by the Engineer, the materials shall be stored under cover the suitably painted for the projection against weather. Any material, which has deteriorated or has been damaged shall be removed from site and replaced by new members, as directed by the Engineer at no extra cost and time.

A. Steel to be used in fabrication shall be stored in separate stacks clear of the ground, section wise and lengthwise.

B. The storage area shall be kept clean and properly drained. Structural steel shall be so stored and handled to such a manner that members are not subjected to excessive stresses and damage. Girders and beams shall be placed in upright position. Long members shall be supported on closely spaced skids to avoid unacceptable deflection.

11.1.11.2 Storage Yard

A. The Contractor shall be required to establish a suitable yard, at an approved location at site for storing the fabricated steel structures and other materials which will be delivered to site. The yard shall have proper facilities such as drainage and Lighting including access for cranes, trailers and other heavy equipment's.

B. The Contractor shall have been deemed to have visited the site, prior to submission of his tender, to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc., all of which shall be carried out by the Contractor at his own cost and as directed by the Engineer.

11.1.11.3 Covered Store

All field connection materials, paints etc. shall be stored on racks and platforms, off the ground in a properly covered building by the Contractor.

1.2 Field Bolts

1. Requirements stipulated under bolting shall apply for field bolts. Field bolts, nuts and washers shall be supplied by the authorized fabricators of the structural member in excess of the nominal numbers required. Only HSFG bolts of class 8.8 or higher as per GFC drawings shall be used.
2. At the time of assembly, the surfaces in contact shall be free of paint or any other applied finish, oil, dirt, loose rust, loose scale, burrs and other defects which would prevent solid seating of the parts or would interface with the development of friction between them.
3. In any other surface condition, including a machined surface, is specified, it shall be the responsibility of the Contractor to work within the slip factor specified for the particular case.
4. Each bolt and nut shall be assembled with washers of appropriate shape, quality and number in cases where plane parallel surfaces are involved. Such washers shall be placed under the bolt head or the nut, whichever is to be rotated during the tightening operation. The rotated nut or bolt head shall be tightened against a surface normal to the bolt axis, and the appropriate tapered washer shall be used when the surfaces are not parallel. The angle between the bolts axis and the surface under the non-rotating component (i.e., the bolt head or the nut) shall be 90 ± 3 degree. For angles outside these limits, a tapered washer shall be placed under the non-rotating component. Tapered washers shall be correctly positioned.
5. No gasket or other flexible material shall be placed between the holes. The holes in parts to be joined shall be sufficiently well aligned to permit bolts to be freely placed in position. Driving of bolts is not permitted. The nuts shall be placed so that the identification marks are clearly visible after tightening. Nuts and bolts shall always be tightened in a staggered pattern and where there are more than four bolts in any one joint, they shall be tightened from the centre of the joint outwards.
6. If, after final tightening, a nut or bolt gets slackened off for any reason, the bolt, nut and washer or washers shall be discarded and not used again.
7. Procedure for Installation and checks of HSFG Bolts and nuts assembly shall be as per Cl. 28.10.5 to 28.10.11 of IRS-B1 (Including Correction slips up to 11 or latest)

11.3 Structural Steel Work Painting Works**11.3.1 General****11.3.1.1 Scope of specification**

This Specification covers the scope of painting, methods for the surface preparation, application of paints and precautions to be taken for the painting of structural steel work. It covers the supply and delivery of all necessary materials, labour, scaffolding, tools, equipment and everything that is necessary for the job completion on schedule.

11.3.1.2 Applicable Codes for painting works:

The following Specifications, Standards and Codes are included as part of this Specification. All standards and Codes of practice referred to herein shall be the current editions during the currency of project including all applicable official amendments and revisions.

In case of discrepancy between this Specification and those referred to herein, this specification shall govern. In case of discrepancy between Contract drawings and this specification, the Contract drawings shall govern.

IS: 159 (2024)	Ready Mixed Paint, Brushing, Acid Resisting-Specification.
IS:384:(2002) (RA2018)	Brushes, Paints and Varnishes, Flat.
IS:384 Part 1:2023	Flat Brushes for Paints and Varnishes - Specification – Part 1 Heavy Duty.
IS:384 Part 2:2023	Brushes, Paints and Varnishes, Flat-Specification – Part 2 Household Purposes.
IS: 487 (2023)	Brushes, Paints and Varnishes - Oval, Ferrule Bound; And Round, Ferrule Bound.
IS: 958 (2020)	Temporary Corrosion Preventives, Grease Type, Soft Film Specification (Third Revision).
IS:1153 : 2021	Temporary Corrosion Preventives Hard Film Solvent Deposited.
IS:1477: Part 1: 1971 (RA2020)	Code of Practice for Painting of Ferrous Metals in Buildings - Part 1 : Pre-treatment.
IS:1477: Part 2:1971 (RA2020)	Code of practice for painting of ferrous metals in buildings: Part 2 Painting.
IS 1154 : 2022	Temporary Corrosion Preventive Fluid, Soft Film, Solvent Deposited, Water Displacing — Specification.
IS 2074 : 2023	Ready Mixed Paint, Air Drying, Red Oxide-Zinc Chrome, Priming-Specification.

11.3.2. Products and Materials

11.3.2.1. Paint

1. All paint delivered to the site shall be ready mixed, in original sealed containers, as packed by the paint manufacturers, and no thinners shall be permitted.
2. Paint shall be stirred frequently to keep the pigment in suspension.

11.3.2.2. Protection of Paintwork

1. The Contractor shall provide measures as necessary to prevent damage to the work and to other property or persons through all cleaning and painting operations. Paint or paint stains which result in other unsightly appearance on surfaces not designated to be painted shall be removed or obliterated by the contractor at this cost.
2. All painted surfaces that in the opinion of the Engineer are damaged in anyway, shall be repaired by the contractor at his own cost with materials and to a condition equal to that of the requirements specified in these specifications.

3.

f in the opinion of Engineer, any other work would have caused dust, grease or foreign materials to be deposited upon the painted surfaces, the painted surfaces shall be thoroughly cleaned. At the time of commissioning of the work, the painting shall be completed and the surfaces shall be undamaged and clean.

4. The areas for high-strength bolts shall be protected by masking tape against undercoat application at the fabrication shop. Immediately prior to erection any rust in the paint are shall be removed by power wire brushing to a standard equivalent to SA3.

11.3.2.3. Site painting

After the steel work is erected at site a second cover coat of Aluminium paint to IS:2339 (brushing or spraying as required) shall be applied after touching up the primer and the cover coat given in the shop if damaged in transit (As per IRS-B1)

11.4 Additional Specifications for Launching

- Preferably no road traffic blocking will be used. Multiple day / night short blocks of 1h to 1h30 maximum are acceptable to ensure safety.
- Contractor has to provide his own proposed launching scheme and supporting calculations with the proposal and take approval from BMRCL and Railways (for Railway span).
- Approval of Launching Scheme, method statement and Launching Scheme Drawing, Design have to be got approved from IIT/IISc as per the requirement of Railways at no extra cost.
- Contractor has to provide principles of nose / truss connection details if required.
- Truss design composite girder requirements will govern over nose / launching equipment requirements.
- Contractor will submit and get approval from Engineer of the detailed design of the full launching equipment and scheme before starting the launching.
- Contractor will coordinate with railways, Bangalore Traffic Police and Engineer before and during the launching. Contractor to develop detailed traffic diversion scheme.
- For location of storage and fabrication yard relevant clause shall be referred.
- Any necessary precaution by proper and secure fixing shall be taken by the contractor to prevent the fall of any object onto the road below during the whole erection period.

11.4 Mode of Measurement

Unless otherwise specified the cost of steel bridge girder is included under the relevant schedule of items in BOQ. In case it is specified to be paid separately, then the unit rate shall include the following:

- a. Erection of fabricated parts (fabrication and transportation of various parts / components including HSFG bolts / nuts / washers from workshop to storage yard will be done by approved sub-contractors).
- b. Receiving, unloading and keeping in safe custody and upkeep of all fabricated parts including HSFG bolts / nuts / washers at storage yard.
- c. Loading, transportation and unloading of all fabricated structural steel materials including HSFG bolts / nuts / washers from site storage yard to erection site, handling, assembling, bolting, welding if necessary and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and / or as directed by the Engineer.

- d. Tightening of HSFG bolts for the field erection of fabricated parts. However, supply of HSFG bolts and its compatible nuts and washers will be arranged / supplied at the storage yard by approved sub-contractor.
- e. Preparation of complete detailed erection drawings and detailed calculation based on suggested erection sequence and design drawings as given by Engineer or alternative scheme proposed by contractor and approved by Engineer.
- f. Preparation of complete detailed fabrication drawings for all temporary structures such as temporary nose, staging, temporary support, bracing required for all permanent and temporary structures.
- g. All tools, plants and equipment's / machinery.
- h. All other consumables including fuel and lubricants etc.
- i. All safety and protection arrangements to be made at site / storage yards for road users, public and workmen.

SECTION – S.12

13. ROADWORK

12.1 Control of Traffic

The contractor shall take all necessary precautions in co-ordination with and to the requirements of all the competent authorities concerned to protect the work from damage until such time as the seal coat or surface treatment has developed sufficient strength to carry normal traffic without any damage to it.

The new work shall be opened to traffic only after it is authorized by the Engineer. The contractor shall submit a detailed traffic diversion/or control and regulation plan taking all safety measures during the course of work permitted by the concerned authorities to the Engineer for his consent before start of work.

The contractor shall take all precautions to avoid or minimize delays and inconvenience to road users during the course of the work. Where adequate detours or side tracks are available, traffic shall be temporarily diverted while the work is in progress depending on volume of traffic and subject to approval by Traffic Police. Adequate signs, signals, barriers and lamps for the warning and guidance of traffic shall be provided at all times during the course of the work till it is opened to traffic.

The Contractor shall take all reasonable precautions to protect traffic against accident, damage or disfigurement by construction equipment, tools, and materials, splashes and smirches of bitumen/ bituminous material or any other construction materials and shall be responsible for any claims arising from such damage or disfigurement. Traffic signs erected shall be in accordance with the IRC Standards and/or as prescribed and approved by the Traffic Police Department.

12.2 Granular Sub-Base (Non-Bituminous)

This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these specifications or as per MORTH standards, as acceptable to Highway authorities & road owing agency. The material shall be laid in one or more layers according to lines, grades and cross-sections shown on the drawings.

12.2.1 Material

The Material to be used for the work shall be natural sand, moorum, gravel, crushed stone, or combination thereof depending upon the grading specified in MORTH specifications for Roads and Bridges. The material shall be free from organic or other deleterious constituents.

12.2.2 Physical requirements

The material shall have a 10 percent fines value of 50 KN or more (for sample in soaked condition) when tested in compliance with BS:812 (Part III). The water absorption value of the coarse aggregate shall be determined by IS:2386 (Part 3); if this value is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS: 383. CBR Value shall be determined at the density and moisture content likely to be developed in equilibrium conditions which shall be taken as being the density relating to a uniform air voids content of 5 percent.

12.2.3 Strength of sub-base

It shall be ensured prior to actual execution that the material to be used in the sub-base satisfies the requirements of CBR and other physical requirements when compacted and finished.

12.2.4 Construction Operations

1. Preparation of sub-grade

Immediately prior to the laying of sub-base, the sub-grade already finished or existing surface shall be prepared by removing all vegetation and other extraneous matter, lightly sprinkled with water if necessary and rolled with two passes of 80 – 100 KN smooth wheeled roller. Damage to the subgrade shall be made good before sub base is laid.

2. Spreading and compacting

The approved sub-base material shall be spread on the prepared sub-grade by a grader of suitable type and adequate capacity.

When the sub-base material consists of combination of materials, mixing shall be done mechanically by the mix-in-place method.

The equipment used for mix-in-place construction shall be approved equipment capable of mixing the material to the desired degree.

Moisture contents of the loose material at the time of compaction shall be checked in accordance with IS: 2720 (Part 7) and suitably adjusted. Rolling procedure shall be as described under relevant Subsection except stated herein.

Rolling shall be continued till the density achieved is at least 98% of the maximum dry density for the material determined as per IS:2720 (Part 8).

12.2.5 Control of Traffic

Control of traffic shall be as described under Subsection 12.1.

12.3 Water-bound Macadam Sub-base/ Base (Non-Bituminous)

12.3.1 Description

The work shall consist of furnishing, placing, watering and compacting sub-base material mechanically interlocked by rolling and bounded together with screening and/ or binding material to the required degree on a prepared sub-grade/ sub-base or the existing surface as the case may be in accordance with these Specifications, and to the lines, levels, grades, dimensions and cross sections as shown on Drawings and/ or required by the Engineer.

12.3.2 Materials

1. Coarse aggregate

The coarse aggregates shall be hard and durable crushed stones, free from deleterious matter conforming to one of the gradings as set forth in Table 12.3.1, the physical requirements given in Table 12.3.2 subject to the Engineer's consent.

2. Screenings

Screenings to fill voids in the coarse aggregate shall generally consist of the same material as the coarse aggregate or of gravel (other than round material) or moorum as approved by Engineer. However, where permitted non-plastic material such as moorum may be used for this purpose provided liquid limit and plasticity index of such material are below 20 and 6 respectively and fraction passing through 75 micron sieve does not exceed 10 percent.

3. Binding material

Binding material to be used for water-bound macadam as a filler material meant for preventing ravelling, shall be a suitable material and having a Plasticity Index (PI) value of less than 6 as determined in accordance with IS : 2720 (Part-5).

Table 12.3.1
Grading requirements of coarse aggregates

Grading	Size Range	IS Sieve Designation	Percent Passing by weight
1	90 mm to 45 mm	125 mm 90 mm 63 mm 45 mm 22.4 mm	100 90-100 25-60 0-15 0-5
2	63 mm to 45 mm	90 mm 63 mm 53 mm 45 mm 22.4 mm	100 90-100 25-75 0-15 0-5
3	53 mm to 22.4 mm	63 mm 53 mm 45 mm 22.4 mm 11.2 mm	100 95-100 65-90 0-10 0-5

Note: The compacted thickness for a layer with Grade 1 shall be 100 mm while for a layer with Grade 2, it shall be 75 mm.

Table 12.3.2

Physical requirements of coarse aggregates or water-bound macadam sub-base and base courses

S.No	Test	Test Method	Requirement (Maximum)
	*Los Angeles Abrasion value or	IS :2386 (Part-4)	50 per cent
	* Aggregate Impact value	IS :2386 (Part-4)	40 per cent
	*Flakiness Index	IS :2386 (Part-1)	15 per cent

*

Aggregate may satisfy requirements of either of the two tests

12.3.3 Construction Method

1. Preparation of Sub-grade/ sub-base

- a) The surface of the sub-grade/ sub-base or existing surface shall be shaped and prepared to the lines, levels, grades, dimensions and cross sections as shown on the Drawings. Damage to or deterioration of sub-grade/ sub-base shall be made good before sub-base/ base is overlaid.

b) Inverted Choke

If water bound macadam is to be laid directly over the sub grade, without any intervening pavement or soling course, a 25 mm course of screenings or coarse sand shall be spread and compacted on the prepared subgrade before application of the coarse aggregate. In case of fine sand or silty or clayey sub grade, a 100 mm insulating layer of screenings or

- coarse sand shall be laid, the gradation of which will depend on drainage requirements. Alternatively, appropriate geosynthetics performing functions of separation and drainage layer may be used over the prepared sub-grade subject to the satisfaction of the Engineer.
2. Spreading coarse aggregates
 - a) The coarse aggregates of specified size and grading shall be spread uniformly in layers with each compacted layer thickness not more than 100mm for Grading 1 and 75 mm for Grading 2 and in a manner that prevents segregation into fine and coarse materials.
 - b) Sub-base/ or base material shall contain moisture nearly equalizing the optimum moisture content at the time of compaction.
 - c) Immediately after each layer has been spread and shaped satisfactorily, each layer shall be thoroughly compacted with suitable and adequate compaction equipment. Rolling operations shall begin from the outer edge of roadbed towards the centre, gradually in a longitudinal direction; except on super-elevated curves, where rolling shall begin at the lower edge and progress towards the upper edge. The rolling shall be continued until the aggregates are thoroughly keyed, well-bounded and firmly set in its full depth.
 3. Tolerance

The finished sub-base/ base at any point shall not vary more than 15mm below and 12mm above the planned grade or adjusted grade with 3m straight edge applied to the surface parallel to the centerline of the road. With the template laid transversely the maximum permissible variation from specified profile shall be 12mm and 8mm respectively.

The sub-base/ base course completed in each day's work shall have an average thickness not less than the required thickness. Sub-base/ base course which does not conform to the above requirements shall be reworked.

12.4 Bituminous Materials

12.4.1 Materials

Materials shall meet the requirements of the relevant IS Codes. These shall be of the following types.

1. Cut back Bitumen

1.1 Cut back bitumen shall be Rapid Curing (RC), Medium Curing (MC) or Slow Curing (SC) conforming to IS : 217.

2. Cationic Emulsion

Bitumen emulsions of the cationic type for roads shall conform to IS: 8887. Emulsified bitumen shall be Rapid Setting (RS), Medium Setting (MS), or Slow Setting (SS). The physical and chemical requirements of the three types emulsions shall comply with the requirements specified in Table 1 of IS: 8887.

3. Paving Bitumen

Paving bitumen shall be conforming to IS: 73 and of the following two types:

Type 1 Paving bitumen from non-waxy crude shall satisfy the requirements given in Table 1 of IS: 73.

Type 2 Paving bitumen from waxy crude shall satisfy the requirements given in Table 2 of IS: 73. The temperature at application of bituminous materials shall be maintained as per manufacturer's instructions and/or as directed by the Engineer's Representative.

An anti-stripping and Bonding agent should be used in all final restoration road works. It should conform to IS: 14982-2001 Specifications. The percentage can be from 0.5% to 1.25% by weight of bitumen content. The optimum dose can be ascertained using M.O.S.T. / BIS guidelines.

12.4.2 Methods of Storage and Handling

Asphaltic material shall be handled and stored with due regard for safety and in such a way that at the time of use in the work the material conforms to the Specifications. Following precautions shall be taken while using these materials:

1. Work with these materials shall be carried out in good weather conditions and it shall be carried out in warm and dry weather, and not in wet or extremely cold weather.
2. Emulsified asphalt shall be handled with care and not subjected to mechanical shocks or extremes of temperature likely to cause separation of the asphalt. Emulsified asphalt showing sign of separation shall not be used.
3. During heating, no water or moisture shall be allowed to enter the boiler.
4. Heating of bitumen shall be done to the correct temperature range, as prescribed by the manufacturer for the grade used. The temperature shall be controlled with the use of a suitable thermometer, and the material shall be drawn and used while still at such temperature as is prescribed by manufacturer or in accordance with MOST specifications.
5. It shall be ensured that mixing of ingredients is thorough and all particles of aggregates are coated uniformly and fully.

12.5 Prime Coat**12.5.1 Description**

This work shall consist of the cleaning and preparing of the surface to be primed to specified lines, grade, and cross-section, booming and clearing thoroughly and applying bituminous material in accordance with these Specifications.

12.5.2 Materials

The choice of the primer shall depend upon the porosity characteristics of the surface to be primed. The primer shall be Medium Curing Cutback (MC) and the particular grade to be used for the work shall have the consent of the Engineer. Slow setting Cationic emulsion conforming to IS : 8887 may also be used. Sampling and testing of bituminous primer shall be as per IS : 217, IS : 454 and IS : 8887.

12.5.3 Construction Methods**1. Weather Limitations**

Prime coat shall not be applied at a time when the surface is wet or when the weather is foggy, rainy or windy.

2. Equipment

The equipment used for the work shall include a power broom and primer material distributor spraying it uniformly at specified rates and temperatures. It shall be equipped with self-heating arrangement, suitable pump, adequate capacity compressor and spraying bar with nozzles having constant volume or pressure system. Spraying by manual methods may be allowed for inaccessible or small areas with the consent of the Engineer.

3. Cleaning Surface

Immediately prior to applying the prime coat the surface to be primed shall be swept clean from all loose dirt and other objectionable material and shall be shaped to the required lines, grades, cross section.

4. Application of bituminous primer

The primer material shall be applied by means of a distributor at rates usually from 0.8 to 1.4 litres per square metre and at a temperature within the allowable range corresponding to the material used and porosity condition of surface over which it is laid. The temperature

of primer at time of application may vary from 400 C to 600 C for cutback bitumen and 400 C to 600 C for bitumen emulsion

Prime coat shall be allowed to penetrate for at least 48 hours to allow penetration into the base course and aeration of volatile from the primer material, then covered with clean dry sand or stone screening. Areas containing an excess or deficiency of priming material shall be corrected by the addition of sand or primer.

12.6 Tack Coat

12.6.1 Description

This work shall consist of furnishing and applying bituminous material to an existing road surface or to an existing bituminous prime coat surface which has dried out or preparatory to laying another bituminous layer over it.

12.6.2 Materials

The material for tack coat shall be a bituminous or cut back emulsion of suitable type and grade.

12.6.3 Construction Methods

1. Cleaning Surface

The whole surface on which the tack coat is to be applied shall be cleaned of dust and any extraneous material before the start of application of tack coat by using a power broom or any other equipment/ method.

2. Application of tack coat material

The tack coat material shall be applied uniformly by means of a distributor at controlled rates as per MORTH specifications and at the temperature within the allowable range corresponding to the material used. It shall be done with self-propelled or towelled bitumen. Surfaces of structures and trees adjacent to the areas being treated shall be protected in such a way as to prevent their being spattered or marred.

12.7 Bituminous Macadam

12.7.1 Description

The work shall consist of one or more applications of compacted crushed aggregates premixed with bituminous binder (suitable grade) to a primed non-bituminous surface or previously constructed bituminous surface and in conformity with the lines, grades, dimensions and cross-sections shown on the Drawings. This shall comprise of a single course of 50mm to 75mm thickness as specified in the approve or as Directed by Engineer.

12.7.2 Materials

1. Bitumen

The bitumen shall be paving bitumen of suitable grade approved by the Engineer and conforming to IS :73.

2. Additives

Adhesion and Ant-stripping agent shall be added to the bitumen subject to Engineer's consent at the required percentage of additive. The additive shall be thoroughly mixed with the bituminous material in accordance with the manufacturer's instructions.

3. Aggregates

Aggregates shall consist of clean and hard crushed stone free from dust, clay, dirt and any other deleterious matter. The physical requirements shall be as given in Table 12.7.1. Aggregates shall conform to one of the two gradings given in Table 12.7.2 depending on the compacted thickness; the actual grading shall have the consent of the Engineer.

Table 12.7.1

Physical requirements of aggregates for bituminous macadam

	Test	Test Method	Requirement (maximum)
	Los Angeles Abrasion value	IS :2386 (Part-4)	40 per cent
	* Aggregate Impact value	IS :2386 (Part-4)	30 per cent
	Flakiness Index and Elongation Indices (Total)	IS : 2386(Part-1)	30 per cent
	Coating and Stripping of Bitumen aggregate mixtures	AASHTO T-182	Minimum retained coating 95%
	Soundness : (i) Loss with Sodium Sulphate 5 cycles (ii) Loss with Magnesium Sulphate 5 cycles		12 percent 18 percent
	Water absorption IS :	2386(Part-3)	2 per cent

* Aggregates may satisfy requirements for either of the two tests.

IS Sieve Designation	Per cent by weight passing the sieve	
	Grading 1	Grading 2
45.0mm	100	-
26.5mm	75-100	100
22.4mm	60-95	75-100
11.2mm	30-55	50-85
5.6mm	15-35	20-40
2.8mm	5-20	5-20
90.0 micron		

Bitumen content for pre mixing shall be 4% by weight of total mix unless otherwise approved by Engineer.

12.7.3 Construction Method

1. Weather and Control of Work

The work of laying shall not be undertaken during rainy or foggy weather or when the base course is damp or wet, or during dust storm or when the atmospheric temperature in shade is 15°C or less. The Engineer may order work to cease temporarily on account of adverse weather, unsatisfactory condition of materials, equipment or any conditions which he considers may affect the work adversely.

2. Cleaning and Preparation of Surface

Prior to the application of binder, loose dirt and other objectionable material shall be removed from the surface to be treated by means of the power broom or blower or both. If this does not

provide a uniformly clean surface, additional sweeping shall be done by hand, using stiff brushes or similar brooms. The areas inaccessible to the cleaning means shall be cleaned manually. The sweeping shall extend 200mm beyond each edge of the area to be treated.

Adherent patches of objectionable material shall be removed from the surface by steel scraper or other approved method and where the Engineer so directs the scraped area shall be washed down with water and hand brooms.

No application of bituminous material shall be undertaken until the surface has been cleaned to the satisfaction of the Engineer.

Before application of the bituminous material any necessary preliminary patching of the surface of the road (To fill in potholes.) shall be done to the complete satisfaction of the Engineer. Tack coat shall be applied in accordance with these Specifications. Prime coat if required, shall conform to Subsection 12.5.

3. Plant and Equipment

All plant used by the Contractor for the preparation, hauling and placing of asphalt mixtures shall be subject to the consent of the Engineer and shall minimise smock, dust and noxious emission and odours. These shall generally meet the following requirements:

- a. The mixing plant shall be a batching plant and shall have adequate capacity sufficient to supply the finisher on the road continuously when spreading the asphaltic mix at normal speed and required thickness.
- b. Scale for any weigh box shall be designed to be accurate to within 1% of the maximum load required and shall be fully automatically controlled. The Contractor shall provide and have at hand not less than ten 25 kilograms weights for frequent testing of all scales.
- c. Weigh box or hopper shall include a means for accurately weighing each bin size of aggregate in a weight box or hopper, suspended on scales, ample in size to hold a full batch without running over.
- d. The asphaltic materials shall be stored in storage tanks designed to keep the temperature of the asphaltic material at maximum temperature of 1100 C. The properties of the asphaltic material kept in that storage tanks shall be in good condition before mixing. The plant shall be provided with a circulating system to ensure continuous circulation between the storage tank and the mixer.
- e. The plant shall be provided with a cold bin for feeding the aggregates. Bin shall have a calibration gate and a mechanical means to insure uniform feeding of the aggregates into the drier as required by the Engineer.
- f. The rotary drier shall be capable of drying and heating the aggregates to the specified temperature.
- g. The plant shall be provided with plant screens capable of screening all aggregates to the specified sizes
- h. The plant shall include at least 3 hot bins for storing the aggregates fed from the drier after passing through the screen. Each bin shall be provided with an overflow pipe to prevent any backing up of material into other bins.

- i. The plant shall be provided with asphaltic control unit by weighing to obtain the proper amount of asphaltic material in the mix within the tolerance specified for the job-mix.
- j. The batch mixer shall be an approved twin pugmill type and capable of producing a continuous uniform mixture within the job-mix tolerances. The mixer capacity shall not be less than 1,000 kilogram batch.
- k. An armoured thermometer reading from 500 C to 2000 C shall be fixed in the asphaltic feed line at a suitable location near the discharge valve at the mixer unit. The plant shall be further equipped with an electric pyrometer, or other approved thermometric instrument so placed at the discharge chute of the drier as to register automatically or indicate the temperature of the heated aggregate.
- l. The plant shall be equipped with a dust collector.
- m. The plant shall be equipped with accurate positive means to govern the time of mixing and to maintain it constant. The time of mixing shall be divided into two steps, dry mixing and wet mixing. For dry mixing, the aggregate from hot bins shall be mixed for a period of 5-15 seconds. For wet mixing, the mixing time shall begin with the start of the asphalt spray after dry mixing. The wet mixing shall take about 30-45 seconds. The mixing time shall be extended if in the consideration of the Engineer the material obtained is not homogeneous.

4. Equipment for Hauling and placing

- a. Trucks for hauling asphaltic mixtures shall have tight, clean, and smooth metal beds that have been sprayed with soapy water, thinned fuel oil, or lime solution to prevent the mixing from adhering to the beds (The amount of sprayed fluid shall however be kept to the practical minimum. Each load shall be covered with a canvas or other suitable material of such size as to protect the mixture from the weather). Any truck causing excessive segregation of material by its spring suspension or other contributing factors, or that shows oil leaks in detrimental amounts, or that causes undue delays, shall upon direction of the Engineer be removed from the work until such conditions are corrected.
- b. The equipment for spreading and finishing shall be mechanical, self powered pavers, capable of spreading and finishing the mixture true to the lines, grades, dimensions and cross sections. The pavers shall be equipped with hoppers and distributing screws of the reversing type to place the mixture evenly.

The pavers shall maintain trueness of grade and confine the edges of the pavement to true lines without the use of stationary side forms. The equipment shall include blending or joint leveling devices for smoothing and adjusting longitudinal joints between lanes. The assembly shall be adjustable to give the cross-section shape prescribed and shall be so designed and operated as to place the thickness or weight per square metre of material required.

Pavers shall be equipped with activated screeds and devices for heating the screeds to the temperature required for the laying of the mixture without pulling or marring.

The term "screed" includes any cutting, crowing, or other practical action that is effective in producing a finished surface of the evenness and texture specified, without tearing, shoving, or gouging.

If, during construction, it is found that the spreading and finishing equipment in operation leaves in the pavement surface tracks or indented areas or other objectionable irregularities, the use of such equipment shall be discontinued and other satisfactory spreading and finishing shall be provided by the Contractor forthwith.

5. Preparation and transport of mix

Bituminous macadam mix shall be prepared in a hot-mix plant either owned by the Contractor or it may be taken from an approved hot mix plant before supply of mix for the work, consent for the use of the mix shall be taken from the Engineer. The hot-mix plant should be of adequate capacity of batch mix type with the features as described under Subsection 15.7.3(3) or otherwise approved by Engineer unless some work specific features are required and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates. The plant shall meet the overall requirements through stringent quality control practices.

The mineral aggregates shall be dried and heated to a temperature between 1500 C and 1630 C. The contractor shall submit for consent the exact temperature to the Engineer. Surfaces of aggregates shall be clean and free of carbon and unburnt fuel oil. The aggregates, immediately after heating, shall be screened into three or more fractions and conveyed into separate bins ready for combining and mixing with asphaltic material.

The dried mineral aggregates prepared as prescribed above, shall be combined in the plant in the amount of each fraction of aggregate required to meet the job-mix formula for the particular mixture. The proper amount of asphaltic material shall be distributed over the mineral aggregate and the whole thoroughly mixed for a period of at least 30 seconds, or longer if necessary to produce a homogeneous mixture in which all particles of the mineral aggregates are coated uniformly. The total mixing time shall be regulated by a suitable locking means.

The mixture shall when emptied from the mixer be at a temperature between 1500 C and 1630 C even for tolerances.

The mixture shall be transported from the mixing plant to the point of use in vehicles conforming to the requirements of Subsection 15.7.3 (4)(a) unless otherwise approved by the Engineer.

6. Application of the Pre-mix

The application of the mix shall proceed immediately after application of tack coat. The mix shall be spread immediately by means of self-propelled mechanical paver with suitable screeds capable of spreading, tamping, and finishing the mix true to lines, levels, dimensions and cross-sections specified. Any bare or insufficiently filled areas shall be re-treated by the mechanical spreader or covered by hand as necessary to give uniform and complete coverage. Any aggregate spread in excess of the agreed rate shall be scattered and evenly distributed on the road or otherwise removed and stockpiled. The temperature of the mix at the time of laying shall be in the range of 120 or 1600 C.

7. Rolling

After the spreading of the mix, the rolling shall be done by road roller of suitable type and capacity. Rolling shall start as soon as possible after the material has been spread and it shall be completed

within limited time frame, and to meet this, the Contractor shall deploy a set of rollers. Rolling shall be done with care to avoid unduly roughening of the pavement surface. It shall commence at the edges and progress towards the centre longitudinally except that on super-elevated and unidirectional cambered portions, it shall progress from the lower to the upper edge parallel to the centre line of the pavement.

The speed of the rollers shall not exceed 5 kilometer per hour for steel wheeled rollers and 7 kilometer per hour for pneumatic tired rollers and shall be at all times slow enough to avoid displacement of the hot mixture. Any displacements occurring as a result of reversing the direction of the roller or from any other cause shall at once be corrected with rakes and fresh mixture where required. Care shall be exercised in rolling not to displace the line and grade of the edges. Rolling shall progress continuously as may be necessary to obtain uniform compaction while the mixture is in a workable condition and until all roller marks are eliminated.

Heavy equipment or rollers shall not be permitted to stand on the finished surface until it has thoroughly cooled or set.

Any petroleum products dropped or spilled from the vehicles or equipment employed by the Contractor upon any portion of the pavement under construction is cause for the removal and replacement of the contaminated pavement by the Contractor.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding premixed material. Rolling shall then be continued until the entire surface has been rolled to 95 % of the average laboratory density, and there is no crushing of aggregates. and all roller marks are eliminated. In each pass of the roller, preceding track shall be overlapped uniformly by at least 1/3rd width. The roller wheels shall be kept damp to prevent premix from adhering to the wheels and being picked up. In no case shall fuel/ lubricating oil be used for this purpose.

Along kerbs, man-holes etc., and at any other locations where proper consolidation by rollers is not practicable, alternative means such as steel rammers shall simultaneously be used to secure adequate consolidation.

12.7.4 Surface Control

1. Surface Regularity

Maximum permissible undulation in longitudinal profile with 3m straight edge shall be as 12mm. Maximum permissible variation from specified cross profile under camber template shall be as 8mm. Surface evenness requirements in respect of both longitudinal and cross profiles should be simultaneously satisfied.

Tests for conformity with the specified crown and grade shall be made immediately after initial compaction, and variations shall be corrected by removing or adding materials as may be necessary. Rolling shall then be continued as specified. After final rolling, the smoothness of the course shall be checked again and any irregularity of the surface exceeding the permissible limits corrected as agreed by the Engineer's Representative, including removal and replacement.

2. Surface Finish

The bituminous macadam shall be covered with either the next pavement course or wearing course, as the case may be, without any delay. If there is to be any delay, the course shall be covered with the seal coat. The seal coat in such cases shall be considered incidental to the work and shall not be paid separately.

12.7.5 Control of Traffic

This shall be as described under Subsection 12.1 above.

12.8 Open-graded Pre-mix Carpet

12.8.1 Description

This work shall consist of laying and compacting an open-graded carpet generally of 20mm thickness or as otherwise specified in a single course composed of suitable small sized aggregates premixed with a bituminous binder on a previously prepared base to serve as a wearing course.

12.8.2 Materials**1. Binder**

Binder shall be bitumen of suitable grade meeting the requirements of the work and other environmental conditions. This shall be conforming to the requirements of IS : 73, IS : 217 and IS : 454 or other approved cut back bitumen as applicable.

2. Coarse aggregates

Coarse aggregates consist of crushed stones and shall be clean, strong, durable, and free from organic or other deleterious materials. The aggregates shall be hydrophobic and of low porosity. If hydrophilic aggregates are to be used, bitumen shall preferably be treated with anti-stripping agents of approved quality in suitable doses.

The aggregates shall meet the requirements given in Table 12.7.1 except that the water absorption shall be limited to 1 per cent. The Stone Polishing Value as measured by BS : 812-(Part-114) shall not be less than 55.

3. Proportioning of Materials They shall comprise of a mix of stone chipping 13.2mm size (passing 22.4 mm sieve and retained on 11.2 mm size) and 11.2 mm size (passing 13.2 mm sieve and retained on 5.6 mm sieve.)

The contractor shall propose material proportions to the Engineer for his consent.

12.8.3 Construction Methods

1. **Weather and Control of Work** This shall be as carried out per Subsection 12.7.3(1).
2. **Cleaning and Preparation of Surface** This shall be as carried out per Subsection 12.7.3(3).
3. **Tack Coat** This shall be applied as per Subsection 12.6.
4. **Preparation and transport of Premix** The binder shall be heated to a temperature appropriate to the grade of bitumen in boilers of suitable design avoiding local overheating and ensuring a continuous supply.
The aggregates shall be dry and suitably pre-heated to the required temperature before they are placed in a mixer. After about 15 seconds of dry mixing, the heated binder shall be distributed over the aggregates at the rate specified. Mixing shall be continuous and thorough to ensure a homogeneous mixture in which all particles are coated uniformly and the discharge temperature shall be within the specified range.
The mixing of binder with chippings shall be continued until the chippings are thoroughly coated with binder. The mix shall be discharged and immediately transported from mixer to the point of use in suitable vehicles or wheel barrows. The vehicles employed for transport shall be clean and the mix being transported should be covered in transit and protected from any kind of damage.
5. **Spreading and Rolling**
Immediately after the application of tack coat, premixed material shall be spread by means of mechanical paver finisher truly to lines, levels, dimensions and cross section as specified. The areas not covered by the mechanical means shall be treated with manual means for which the Engineer has given his consent.
6. **Rolling**
This shall be carried out as per Subsection 12.7.3(7)

12.8.4 Control of Traffic

Subsection 12.1 shall be followed.

12.9 Bituminous Concrete

12.9.1 Description

This work shall consist of a surfacing of single-layer bituminous concrete of specified thickness on previously prepared bituminous surface to the lines, grades, dimensions and cross section as shown

on Drawings. It shall be 25mm/40mm thick as required by Engineer.

Materials

1. Bitumen

The bitumen shall be paving bitumen of suitable penetration grade within the range S 35 to S 90 or A 90 to IS: 73. The actual grade of bitumen to be used shall be appropriate to the requirements of the work and environmental conditions.

2. Coarse aggregates

The aggregates shall satisfy the physical requirements given in Table 15.7.1. Flakiness index shall not exceed 30% and water absorbed not more than 1%

3. Fine aggregates

Fine aggregates shall be the fraction passing 2.36 mm sieve and retained on 75 micron sieve, consisting of crushed run screenings, natural sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from any injurious, soft or flaky pieces and organic or other deleterious substances.

4. Filler

Filter shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement. The filter shall be graded within following limits:

IS Sieve	Per cent passing by weight
600 micron	100
300 micron	95 – 100
75 micron	85 – 100

The filter shall be free from organic impurities and have a Plasticity Index not greater than 4. The Plasticity Index requirement shall not apply if filter is cement or lime. When coarse aggregate is gravel, 2 per cent of mass of total aggregate of Portland cement or hydrated lime shall be added and percentage of fine aggregate reduced accordingly. Cement or lime is not required when the gravel is lime stone.

5. Aggregate gradation

Mineral aggregates, including filler shall be so graded or combined as to conform to grading set forth in Table 15.9.1 below.

Table 12.9.1

Sieve Designation	Per cent by weight passing through sieve for		
	25mm thick Grade 1	25-40mm thick Grade 2	>40mm thick Grade 1
26.5mm			100
22.4mm		100	75-100
13.2mm	100	80-100	--
11.2mm	90-100	75-95	50-85
5.6mm	60-80	55-75	20-40
2.8mm	40-55	40-55	5-20
710micron	20-30	20-30	--

300micron	15-25	15-25	--
180micron	10-20	10-20	--
90micron	5-11	5-11	0.5

12.9.2 Mix Design

1. Requirement of Mix

Apart from conformity with grading and quality requirements of individual ingredients, the mix shall also meet the requirements set forth in Table 15.9.2.

Table 12.9.2

S.no	Description	Requirements
	Marshall stability (ASTM Designation : D-1559) determined on Marshall specimens compacted by 75 compaction blows on each end	820 Kg (1800 pounds)
	Marshall flow (mm)	Minimum 2-4
	Per cent air voids in mix	3-5
	Per cent voids in mineral aggregate (VMA)	Minimum 11-13
	Percent voids in mineral aggregates filled by bitumen (VFB)	65-75
	Binder content, per cent by weight of mix	Minimum 4.5
	Water sensitivity (ASTM : D-1075) loss of Stability on immersion in water at 60 deg. C	Minimum 75% Retained strength
	Swell Test (Asphalt Instt. MS-2, No. 2)	Maximum 1.5%

3. Binder content

Binder content shall be so determined as to achieve the requirements of the mix set forth in Table 12.9.2. Marshall method for arriving at binder content shall be adopted.

4. Job Mix Formula

Before starting work the Contractor shall submit to the Engineer for his consent. The job mix formula for the mixture shall fix a single percentage of aggregate passing each required sieve size, a single percentage of asphalt to be added to the aggregate, and a single temperature at which the mixture is to be delivered on the road, all of which shall fall within the ranges of the composition and the temperature limits. The formula shall give the following details:

I. Source and location of all materials

II. Proportions of all materials as described under :

Binder	-	as percentage by weight of total mix
Coarse aggregate/ Fine aggregate/ Mineral Filler	-	as percentage by weight of total aggregate
		including Mineral Filler

III. A single definite percentage passing each sieve for the mixed aggregate (Vide Table 12.9.1)

IV. The results of test as per specifications obtained by the contractor

V. Test results of physical characteristics of aggregates to be used

VI. Mixing temperature and compacting temperature

4. Application of job-mix formula and Allowable Tolerances

The approved job mix formula shall remain effective unless and until modified. Each day as many samples of the materials and mixtures shall be taken and tested considers necessary for checking the required uniformity of the mixture.

All mixture furnished shall conform to the job-mix formula within the range of tolerances set in forth in Table 12.9.3.

Table 12.9.3
Permissible variations from the job-mix formula

S.no	Description of Ingredients	Permissible Variation by Weight of Total mix in Percentage
	Aggregate passing 13.2mm sieve and larger	+/- 8
	Aggregate passing 9.5mm sieve and 4.75mm sieve	+/- 7
	Aggregate passing 2.36mm sieve & 1.18mm sieve	+/- 6
	Aggregate passing 600 micron sieve & 300 micron sieve	+/-5
	Aggregate passing 150 micron sieve	+/-4
	Aggregate passing 75 micron sieve	+/-3
	Binder	+/-0.3
	Mixing Temperature (Centigrade)	+/-10

When unsatisfactory results or changed conditions make it necessary, a new job mix shall be submitted to the Engineer.

Should a change in a material be encountered or should a change in a source of material be made, a new job mix formula shall be submitted before the mixture containing the new material is delivered.

12.9.3 Construction Methods

1. Weather Limitation

The control over the weather conditions shall be as described under Subsection 12.7.3 (1) above.

2. Progress of Work

No work shall be performed when there is insufficient hauling, spreading or finishing equipment, or labour to ensure progress at a rate not less than 75% of the capacity of the mixing plant.

3. Preparation of Existing Surface

The surface on which the mix is to be laid shall be swept thoroughly and cleaned of all loose dirt and other objectionable material using mechanical broom immediately before start of work. In portions where mechanical means cannot reach, the surface shall be prepared, shaped and conditioned to specified levels, grade and cross-fall (camber).

4. Preparation of Mix

A Hot-mix plant of adequate capacity and capable of producing a proper and uniform quality mix shall be used for preparing the mix. The plant may be either a weigh batch type or volumetric proportioning continuous or drum mix type. The plant shall have co-ordinated set of essential units capable of producing uniform mix as per the job-mix formula.

The temperature of the binder at the time of mixing shall be in the range of 150 to 163 degree C and of aggregates in the range of 155 to 163 degree C, provided also that at no time shall the difference in temperature between the aggregates and binder exceed 14 degree C. The Contractor shall submit the exact temperatures and total mixing time for the consent of the Engineer. Mixing shall be thorough to ensure that a homogeneous mixture is obtained in which all particle of mineral aggregates are coated uniformly.

5. Transportation and Delivery of Mix.

The mix shall be transported from the mixing plant to the point of use in suitable tipper vehicles. The vehicles employed for the transport shall be clean and be covered in transit.

6. Spreading and Finishing

The mix transported from the hot mix plant to the site and shall be spread by means of a self-propelled mechanical paver with suitable screeds capable of spreading, tamping and finishing the mix to specified grade, elevation, and cross-section. However, in restricted locations and narrow widths, where available equipment cannot be operated, other suitable means shall be employed subject to the consent of the Engineer. The mixture shall be laid upon an approved surface and only when weather conditions are considered suitable. The temperature of the mix, at the time of laying, shall be in the range of 120 degree C to 160 degree C.

The prime coat and tack coat to be applied shall be as per Subsections 12.5 and 12.6 respectively.

Spreading, finishing and compacting of the mix shall be carried out during daylight hours only, unless satisfactory illumination is provided by the Contractor.

7. Compaction of Mixture

Immediately after spreading of mix by paver, it shall be thoroughly and uniformly compacted by rolling with a set of self-propelled rollers moving at a speed not more than 5 km per hour, immediately following close to the paver. Generally with each paver, two steel wheeled tandem rollers and one pneumatic tired roller will be required. The initial or breakdown rolling shall be with 8 to 10 ton static weight smooth three wheeled steel roller and finish rolling with 6 to 8 ton tandem roller. The breakdown mrolling shall preferably be followed by an intermediate rolling with a smooth wheel pneumatic roller of 10 to 25 ton having a tire pressure of 7kg/sqcm moving with a speed not more than 7 km per hour and shall be at all times slow enough to avoid displacement of the hot mixture. Means shall be provided for checking and adjusting the tire pressure on the job at all times. All compaction operations, i.e., breakdown rolling can be accomplished by using vibratory roller of 8 to 10 ton static weight. During initial or breakdown rolling and finished rolling, the vibratory shall be switched off. The joints and edges shall be rolled with a 8 to 10 ton three wheeled static roller. No delays in rolling the paved surface shall be tolerated, the breakdown roller must be right up to the paver at all times and the intermediate pneumatic roller right up to the

breakdown roller. The compaction of the asphaltic concrete shall be controlled by temperature as follows:

Roller	Temperature
Breakdown	120°C - 135°C
Pneumatic	95°C - 115°C
Finishing	< 65°C

Rolling procedure shall be as specified under Subsection 12.7.3 (7).

Rolling shall be continued till the density achieved is at least 98% of that of laboratory Marshall specimen. Rolling operations shall be completed in all respects before the temperature of the mix falls below 100 degree C.

8. Joints

Both longitudinal and lateral joints in successive courses shall be staggered so as not to be one above the other. Longitudinal joints and edges shall be constructed true to delineating lines parallel to the centre line of the road.

Longitudinal joints shall be offset by at least 150mm from those in the lower course.

Longitudinal and transverse joints shall be made in a careful manner so that well bonded and sealed joints are provided for the full depth of the course.

Surface regularity

Surface shall be tested for undulations in longitudinal and cross profiles with 3 m straight edge and crown template respectively. Crown template shall conform to the typical cross section.

Maximum permissible undulation in longitudinal profile with 3m straight edge shall be as 8mm.

Maximum permissible variation from specified cross profile under camber template shall be as 4mm.

Surface evenness requirements in respect of both longitudinal and cross profiles should be simultaneously satisfied.

Protection of the pavement from traffic

Subsection 12.7.5 shall apply except as stated below.

Section of the newly finished works shall be protected from traffic of any kind until the mixture has cooled to approximately ambient air temperature and well set.

12.10 Seal Coat

12.10.1 Description

This work shall consist of application of a seal coat for sealing the voids in a bituminous surface laid to the specified levels, grade, and cross fall. Seal coat used shall be of premix type unless otherwise approved by the Engineer.

12.10.2 Materials

1. Binder

The binder shall be bitumen of a suitable grade appropriate to the requirements of the work and other environmental conditions as directed by the Engineer and satisfying the requirements of IS : 73, 217, 454 or other cut back as applicable.

2. Aggregates

The aggregates shall be sand or grit and shall consist of clean, hard, durable, dry particles and shall be free from dust, soft or flaky/ elongated material, organic matter or other deleterious substances. The aggregates shall pass 2.36mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cum per 10 sq m area.

12.10.3 Construction Methods

1. Preparation of base

The seal coat shall be applied immediately after laying of bituminous course which is required to be sealed. Before application of seal coat materials, the surface shall be cleaned free of any dust or other objectionable matter.

2. Preparation and Application of Mix

Mixtures of approved type shall be employed for mixing aggregates with suitable bituminous binder. The binder shall be heated in boilers of suitable design, to a temperature appropriate to the grade of bitumen. The aggregates shall be clean, dry and suitably heated to a temperature before the same are placed in the mixture. Mixing of binder with aggregates to specified proportions shall be continued till the latter are thoroughly coated with the former.

The mix shall be immediately transported from the mixing plant to the point of use and spread uniformly on the bituminous surface to be sealed.

3. Rolling

As soon as sufficient length has been covered with pre-mixed material, the surface shall be rolled with 8-10 ton smooth wheeled steel, suitable vibratory or other equipment. As regards procedure for rolling it shall be as specified under Subsection 12.7.3 (7).

4. Control of Traffic

Subsection 12.1 shall apply.

12.11 Cement Concrete Pavements

12.11.1 General

This work shall consist of constructing Plain/ or Reinforced Cement Concrete Pavements as required in accordance with these Specification and in conformity with the lines, levels, grades and dimension in accordance with the design.

12.11.2 Materials

1. General

The concrete materials viz. cement, aggregates, water, steel reinforcement, admixtures shall be in accordance with Section 5 on concrete except as specified herein.

2. Dowel and Tie bars Dowel bars shall be plain round bars. They shall be free from burring or other deformation restricting slippage in the concrete. Before delivery to the Works, one half of the length of each dowel bar shall be painted with one coat of bituminous material.

Tie bars shall be deformed bars free from oil, dirt, loose rust and scale.

These shall conform to the requirements of IS : 432, IS : 1139 and IS : 1786 as relevant.

3. Sleeves

The sleeves for dowel bars of expansion joints shall be of plastic material. This shall be designed to cover the dowels specified by the Designer, with a closed end, and with a suitable stop to hold the end of the sleeve a distance equal to the thickness of joint filler or at least 30mm from the end of the dowel bar. These shall be of such design that they do not deflect or collapse during construction, and the arrangement of sleeves shall be in accordance with these Specifications.

4. Waterproof Membrane

Where Waterproof membrane is to be provided, it shall be an impermeable polythene plastic sheeting. Where an overlap of underlay material is necessary this shall be at least 300mm. Water shall not be allowed to pond on the membrane which shall be completely dry when the concrete is laid.

5. Jointing Materials

a. Joint Filler

The expansion joint fillers shall conform to the requirements of IS: 1838. They shall be punched to admit the dowels where called for as specified by the Designer. The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened closely together securely and accurately to shape by stapling or other satisfactory positive fastening.

b. Joint Primer

Joint primer shall be fully compatible with the joint sealant and shall be applied strictly in accordance with the manufacturer's instructions.

c. Joint Sealing Compound

The Sealing Compound of hot poured, elastomeric type shall conform to AASHTO M282 and cold applied sealant shall be in accordance with BS 5212 (Part 2).

12.11.3 Equipment and Tools

1. General

The concrete paving shall be carried out by use of mechanised method. Equipment and tools necessary for handling materials and performing the work shall have the consent of the Engineer as to design, type, capacity and mechanical, condition shall be at the site of the work before work is started. In special cases like a very short length of road to be laid at a location, other methods may be approved by Engineer.

2. Batching and Mixing Plant

This shall be of suitable type, capacity and make meeting the requirements of work.

3. Paving Equipment

The concrete shall be placed with an approved fixed form or slip form paver with independent units designed to (i)spread, (ii)consolidate, screed and float finish, (iii)texture and cure the freshly placed concrete in one complete pass of the machine in such a manner that a minimum of hand finishing will be necessary and so as to provide a dense and homogeneous pavement in conformity with the plans and Specifications.

Vibrators for full width vibration of concrete paving slabs may be either the surface pan type or the internal type. They may be attached to the spread finisher. They shall not come in contact with the joint, sub base or side forms.

The frequency of the surface vibrators shall not be less than 3500 impulses per minute and for the internal type not less than 5000 impulses per minute. The variable vibration setting shall be provided in the machine.

At least two spare vibrators and one generating unit shall be on hand in case of any breakdown of the vibrating equipment being used.

4. Concrete Saw for joint cutting

The mechanical saw for cutting concrete shall be adequately powered to cut rapidly with a water-cooled diamond edge saw blade to the depth required. A water tank with flexible hoses and pump shall be made available in this activity on priority basis. The Contractor shall have at least one standby saw in good working condition.

5. Forms

Straight side forms shall be metal forms having a thickness of at least 5mm and have a depth equal to the prescribed edge thickness of the pavement slab.

Curved forms shall be of the radius called for as specified by the Designer and acceptable flexible forms shall be installed with that radius. Built-up forms with horizontal joints shall not be used. Forms shall be free from kinks, bend or wraps. Forms shall not deflect more than 6 mm when tested as a simple beam with a span of three metres under a load equal to that which the finishers or other construction equipment will exert on them. The top of the form shall not vary from a three metre straight edge by more than 3mm at any point and the side by more than 6mm at any point.

The forms shall contain provision for locking together tightly the ends of abutting from sections and for secure setting.

12.11.4 Construction Methods

1. Preparation of Sub-base

The sub-base, which shall generally be of water-bound macadam (WBM) conforming to Subsection 3.3. The sub base shall be wetted adequately or provided with a water proof membrane so that it does not absorb any water from the concrete to be laid over it. Concrete shall not be placed on any portion of the sub-base until the consent of the Engineer is given.

2. Setting Forms

The sub-base under the forms shall be compacted and cut to grade so that forms, when set to the position are within + 3mm of a straight line formed by the top of the forms. If the sub-base is found to be below the required grade at the form line, the grade line shall be lifted by placing lean concrete mix 1:4:8 beneath the form and setting the form when it is set. Imperfections and variations above grade shall be corrected by tamping or cutting to the degree required.

The alignment and grade elevations of the forms shall be checked and the necessary corrections made by the Contractor immediately before and after placing the concrete. When any form has been disturbed or any roadbed has become unstable, the form shall be reset and rechecked. On final setting of the forms, these shall be checked for at least half the length of pavement to be concreted in a particular day before concreting commences on that day. While concreting long lengths, the setting up of forms to the exact grade and alignment shall be in advance of the concreting operation by at least 60 m.

Forms shall be cleaned and oiled prior to the placing of concrete. The forms shall be removed not earlier than 24 hours after the concrete has been laid.

3. Preparation of Concrete

a Trial Mix / Mix Design

Subsection 12.2.1 shall be followed Minimum grade of concrete to be used is M25.

b. Batching, Mixing and Transporting Materials

Subsection 12.2.4 shall apply.

The Ready-Mixed Concrete (RMC) shall conform to Subsection 12.2.4 (5).

4. Placing Concrete

Concrete shall be placed only on a prepared sub-base as specified in Subsection 3.12.2. No concrete shall be placed around structures until they have been brought to the required grade and alignment nor until expansion joint material has been placed around them.

The concrete shall be spread, compacted and finished by a mechanical paver and in accordance with Subsection 12.11.3 (3). The mixing and placing of concrete shall progress only at such a rate as to permit proper finishing, protecting and curing of the pavement.

The truck mixers, truck agitators and other approved hauling equipment shall be equipped with means for discharge of concrete into the hopper of the paver without segregation of the

materials. In all cases, the temperature of the concrete shall be measured at the point of discharge from the delivery vehicle.

The acceptance criteria regarding level, thickness, surface regularity, texture, finish, strength of concrete and all other quality control measures for hand laid concrete shall be the same as in the case of machine laid work.

The concrete shall be thoroughly consolidated against and along the faces of all forms by means of vibrators inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the sub-base or a side form. In no case shall the vibrator be operated longer than 30 seconds in any location. The vibrator shall be inserted in the concrete and worked along the full length and both sides of a joint.

Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them, but shall not be dumped from the discharge bucket on to a joint assembly. Except at construction joints, concrete shall be shovelled against both sides of the joint simultaneously, maintaining equal pressure on both sides. It shall be deposited to a height of approximately 5 cm more than the depth of the joint, and shall be vibrated avoiding honeycombing/ voids. The vibrator shall be inserted in the concrete and worked along the full length and both sides of the joints.

Subsection 12.2.6 shall also apply.

5. Initial strike-off and Placement of Reinforcement

Where the concrete is laid in two layers, the bottom layer of concrete shall be struck off for the full width between longitudinal construction joint true to crown at the required distance below the finished surface elevation, for placement of reinforcement or for placement of a top layer of the required thickness.

The striking-off shall be accomplished by use of the finishing machine, unless some other approved device is allowed. The reinforcement shall be placed as called for by the Designer and pouring of concrete over it shall only be allowed after placement of reinforcement is proper in all respects and approved by the Engineer.

6. Joints

a General

Joints shall comply with the design approved for the construction.

A strip of the preformed expansion joint filler shall be placed around each structure which extends into or through the pavement before concrete is placed.

b. Transverse Expansion Joints

These shall be formed at the design spacings. The material for a transverse joint shall be assembled at the roadbed, and placed into position as a unit.

c. Transverse Contraction Joints

Transverse Contraction joints shall consist of planes of weakness created by forming or cutting grooves in the surface of the pavement. Transverse contraction joints shall also include load transfer dowel-bars where these are specified by the Designer.

The contraction joints shall be cut as soon as the concrete has undergone initial hardening and is hard enough to take up the load of joint sawing machine without causing damage to the slab.

Grooves shall be at right angles to the centreline of the pavement and shall be true to line, subject to a tolerance of 5 mm in the width of the slab.

Any procedure for sawing joints that results in premature and uncontrolled cracking shall be revised immediately by adjusting the sequence of cutting the joints or the time interval involved between the placing of the concrete and cutting of the joints.

Load transfer assemblies for transverse contraction joints shall consist of dowel bars without sleeves and an approved auxiliary spacing and supporting element.

The assembly shall be placed into position so that the dowels are parallel to the centreline and shall be staked into position in such a way as to hold the assembly securely in position throughout construction.

d. Longitudinal Joints

Longitudinal joints shall be constructed in conformity with the design. Planes of weakness shall be created by forming or cutting grooves in the surface of the pavement in accordance with the applicable provisions of this Section. When adjacent lanes of pavement are constructed separately, steel side forms shall be used which will form a keyway along the construction joint. The bars may be bent at angles against the form of the first lane constructed and straightened into final position before the concrete of the adjacent lane is poured.

e. Transverse Construction Joint

Transverse construction joints shall be placed whenever concreting is completed after a day's work or is suspended for more than duration permissible for continuous pouring of concrete. Joints shall be formed by placing installing bars or suitable bulkhead material so that a vertical face with approved key is formed or shall be butt joints formed with suitable material so that a vertical face is formed with no key. No tie bars shall be necessary when key joints are formed but dowel bars of the same dimensions and at the same spacing as for contraction joints shall be necessary at all butt joints.

7. Finishing

a Machine Finishing

As soon as the concrete has been placed, it shall be struck off and screeded by an approved finishing machine or tools to the grades and cross sections specified by the Designer and to a level slightly above grade so that when properly consolidated and finished the surface of the pavement will be at the exact level and grade. The machine or tool shall go over each area of pavement as many times and at such intervals as necessary to give the proper compaction and to leave a surface of uniform texture, true to grade and cross section.

Excessive operation over a given area shall be avoided. The tops of the forms shall be kept clean by an effective device attached to the machine and the travel of the machine on the forms shall be maintained true without lift, wobble or other variation tending to effect the precision finish.

After concrete has been placed on both sides of the joint and struck off, the installing bar or channel cap shall be slowly and carefully withdrawn, the concrete shall be carefully spaded and additional freshly mixed concrete worked into any depression left by the removal of the installing bar. A diagonal finishing machine shall be used if available.

b. Hand Finishing

A portable screed shall be provided for use. The screed shall be at least 60 cm longer than the width of the slab to be struck off and consolidated. It shall be of approved shape, sufficiently rigid to retain its shape and constructed either of metal or of other material shod with metal. (If necessary, a second screed shall be provided for striking off the bottom layer of concrete).

The screed shall then be placed on the forms and slip along them, without lifting, in a combined longitudinal and transverse shearing motion moving always in the direction in which the work is progressing. If necessary this shall be repeated until the surface is of uniform texture, true to grade and contour, and free from porous areas.

8. Edging at Forms and Joints

After the concrete's initial set, the edges of the pavement along each side of each slab, and on each side of transverse expansion joints, planes of weakness except when sawed transverse construction joints, and emergency construction joints shall be worked with an approved tool and rounded to a radius of 5 mm. A well defined and continuous radius shall be produced and a smooth, dense mortar finish obtained. The surface of the slab shall not be unduly disturbed by tilting of the tool during use.

All joints shall be tested with a straight edge before the concrete has set, and correction shall be made if one side of the joint is higher than the other or if they are higher or lower than the adjacent slabs.

9. Surface Texture

The surface of the carriage-way shall be textured by wire brushing in a direction at right angles to the longitudinal axis of the carriage-way. The pavement shall be given this broomed texturing as soon as surplus water has risen to the surface.

The wire brushes shall be either mechanically operated or manual methods may be allowed depending upon the type of paver being used on the Work. In either case the wire broom shall be not less than 450 mm wide with two rows of spring steel. At least two brooms in working order shall be on the site at all times.

The surface texturing shall be completed before the concrete is in such condition that the surface is torn or unduly roughened by the brooming. The broomed surface shall be free from rough areas, porous areas, irregularities, or depressions.

10. Surface Requirements

After the concrete has hardened sufficiently, the surface shall be given a further test for tureens, using an approved 3 m straight edge laid on the surface. Any portion of the surface, when tested in the longitudinal direction, which shows a variation or departure from the testing edge of more than 3.5mm but not exceeding 7mm shall be marked and immediately ground down with an approved grinding tool until the variation does not exceed 3.5mm.

Whenever the variation or departure from the testing edge is more than 7.0mm the pavement shall be removed and replaced. Such removal shall be of the full depth and width of the slab and at least 3m long.

11. Curing

Immediately after the surface texturing, the surface and sides of the slab shall be cured by approved curing method for not less than 7 days. During this period measures shall be taken to prevent the loss of moisture.

The concrete shall not be left exposed between stages of curing.

The surface shall be inspected regularly to ascertain the earliest time at which it is able to withstand the spreading of moisture retaining material. This shall be by ponding of water or spreading and wetting either two layers of burlap or two mats of cotton / jute or a layer of sand or other approved highly absorbent material. Whatever material is used it shall be kept continuously moist for not less than 7 days and to a degree which will ensure that 100% humidity is maintained adjacent to the concrete surface. A membrane curing compound meeting the requirements of BS 7542 may be used subject to the consent of the Engineer.

Concrete surfaces which are subjected to heavy rainfall within three hours after the curing compound has been applied shall be resprayed by the method and the coverage specified above.

Concrete surfaces to which membrane curing compounds have been applied shall be adequately protected for the duration of the entire curing period from the pedestrian and vehicular traffic, except as required for joint sawing operations and surfaces tests, and from only other cause which will disrupt the continuity of the membrane. The curing membrane so formed shall be maintained intact for a period of not less than 14 days. The entire surface shall be protected from the effects of solar radiation and in addition by the use of frames covered with material with heat and light reflecting properties.

Concrete liable to be affected by running water shall be adequately protected from the damage during the setting period.

12. Removing Forms

Forms shall be removed only after stipulated period and carefully so as to avoid damage to the pavement.

13. Protection of Pavement

The Contractor shall erect and maintain suitable barricades and shall employ watchmen to exclude public traffic and that of his employees and agents from the newly constructed pavement until opened for use. These barriers shall be arranged as not to interfere with public traffic on any lane intended to be kept open and necessary signs and lights shall be maintained by the Contractor clearly indicating any lanes open to the public. Where any stipulated public traffic lane is contiguous to the slab or lane being placed, the Contractor shall provide, erect, and subsequently remove a substantial temporary guard fence along the prescribed dividing line, which shall be maintained there and protected by signages until the slab is opened to traffic. The Contractor's plan of operation shall be such as to obviate any need for encroachment on the public traffic lane or lanes under use .

The same shall be approved by the local competent authority.

Any part of the pavement damaged by traffic or other cause prior to its final acceptance shall be repaired or replaced by the Contractor.

14. Sealing Joints

Before the pavement is opened to traffic, and as soon after the curing period as is feasible, all joints both longitudinal and transverse, shall be filled with the material approved for use as seal.

Both primer and sealing compound shall be treated and applied strictly in accordance with the manufacturer's specifications/ instruction and by use of approved equipment.

The sealing material shall be poured into each joint opening as directed by the Engineer. The pouring shall be done in such a manner that the material will not be spilled on the exposed surfaces of the concrete. Any excess material on the surface of the concrete pavement shall be removed immediately and the pavement surface cleaned.

SECTION- S.13**14. REINFORCED EARTH**

The work shall be carried out as per the Cl. 3100 of latest edition of {MORT&H} as published by Indian Roads Congress.

MEASUREMENT:

The measurement for payment for reinforced soil wall shall be in Square metres of finished work of each face and shall be measured in the plane of final inclination specified in the drawings. The measurement of length shall be the finished work along the length of the road. The measurement of height along the slope shall be done from the top level of the footing on which the fascia element is placed to the top of the capping beam.

The rates shall include cost of material, labour, plant, royalties, handling, storage and transportation expenses, cost of bed block, levelling pads, fascia elements, capping beam, connectors, reinforcing elements, scaffolding, supply of the specified filter media materials including drainage arrangement, supply of soil fill for the reinforced as well as unreinforced zone of the quality specified in the design/ drawings, placing, spreading and compaction through mechanical means.

The rate shall include full compensation for design, drawings and testing of materials.

The rate shall include the cost of investigations, design and construction of ground improvement measures.

Measurement for friction slab and crash barriers shall be in cubic metre and shall be paid separately under relevant item.

SECTION: J -PROJECT WIDE INTERFACE DOCUMENT



BANGALORE METRO RAIL CORPORATION LIMITED (BMRCL)

BANGALORE METRO RAIL PROJECT, PHASE II

PROJECT WIDE INTERFACE DOCUMENT

**COMMON BOOKLET FOR ALL
PACKAGES**

INTERFACES

BANGALOREMETRO RAIL CORPORATION LIMITED (BMRCL)

(A joint venture of Govt. of Karnataka& Govt. of India)

BMTC Complex, 3rd Floor, KH Road

Shanthinagar, Bangalore 560 027

INDIA

DOCUMENT VERSION HISTORY

No.	Date	Revision details	Remarks
Ver-01	Jul 2019	Initial Version	
Ver-02	Oct 2019	Second version after incorporating various inputs from BMRCL	
Ver-03	Mar 2020	Final version after incorporating comments from BMRCL	
Ver-04	Nov 2020	Final version after further refinement in consultation with BMRCL	
Ver-05	Nov 2021	Final version after incorporating the comments made by Civil wing	
Ver-06	May 2023	a. Modified in Chapter Numbers 11.11, 12.6, 12.10, 14.18 and 16.11 b. Newly added in chapter numbers 11.20, 13.20, 16.15, 16.16 and 21.8	

INDEX

1.0	GENERAL REQUIREMENTS	11
1.1.1	INTRODUCTION	11
1.3.6	CONTRACTOR'S INTERFACE MANAGEMENT SYSTEM	19
2.0	ELEVATED CIVIL (VIADUCT & STATION BUILDING) CONTRACTORS INTERFACES	29
2.1.1	INTERFACE WITH DESIGNER / DESIGN WING / CONSULTANTS	29
2.1.2	INTERFACE WITH UTILITY AGENCY	29
2.1.3	INTERFACE WITH ELEVATED (VIADUCT & STATIONS) E&M CONTRACTOR	29
2.1.4	INTERFACE WITH ELEVATED STATIONS FINISHING CONTRACTOR	31
2.1.5	INTERFACE WITH SIGNALING & TRAIN CONTROL (S&TC) CONTRACTOR	31
2.1.6	INTERFACE WITH ROLLING STOCK CONTRACTOR	32
2.1.7	INTERFACE WITH TELECOMMUNICATION (TEL) CONTRACTOR	33
2.1.8	INTERFACES WITH POWER SUPPLY & TRACTION (PST) CONTRACTORS	35
2.1.9	INTERFACE WITH PSD/PSG CONTRACTOR	40
2.1.10	INTERFACE WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR	42
2.1.11	INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR	44
2.1.12	INTERFACE WITH ESCALATOR CONTRACTOR	46
2.1.13	INTERFACE WITH TRACKWORK (TRW) CONTRACTOR	48
2.1.14	INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	50
3.0	UNDERGROUND CIVIL CONTRACTORS' INTERFACES	53
3.1.1	INTERFACE WITH DESIGNER / DESIGN WING / CONSULTANTS	53
3.1.2	INTERFACE WITH UTILITY AGENCY	53
3.1.3	INTERFACE WITH UNDERGROUND E&M CONTRACTOR	53
3.1.4	INTERFACE WITH UG STATIONS FINISHING CONTRACTOR	54
3.1.5	INTERFACE WITH SIGNALING & TRAIN CONTROL (S&TC) CONTRACTOR	55
3.1.6	INTERFACE WITH ROLLING STOCK CONTRACTOR	61
3.1.7	INTERFACE WITH TELECOMMUNICATION (TEL) CONTRACTOR	63
3.1.8	INTERFACES WITH POWER SUPPLY & TRACTION (PST) CONTRACTORS	66
3.1.9	INTERFACE WITH PSD/PSG CONTRACTOR	73
3.1.10	INTERFACE WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR	73
3.1.11	INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR	73
3.1.12	INTERFACE WITH ESCALATOR CONTRACTOR	73
3.1.13	INTERFACE WITH TRACKWORK (TRW) CONTRACTOR	73
3.1.14	INTERFACE WITH TVS CONTRACTOR	74
3.1.15	INTERFACE WITH ECS CONTRACTOR	77
3.1.16	INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	79
4.0	DEPOT CONTRACTORS' INTERFACES	80
4.1.1	INTERFACE WITH DESIGNER / DESIGN WING / CONSULTANTS	80
4.1.2	INTERFACE WITH UTILITY AGENCY	80
4.1.3	INTERFACE WITH DEPOT E&M CONTRACTOR	80
4.1.4	INTERFACE WITH DEPOT FINISHING CONTRACTOR	82
4.1.5	INTERFACES WITH SIGNALING & TRAIN CONTROL (S&TC) CONTRACTOR	83
4.1.6	INTERFACES WITH ROLLING STOCK CONTRACTOR	84
4.1.7	INTERFACES WITH TELECOMMUNICATION (TEL) CONTRACTOR	86
4.1.8	INTERFACES WITH POWER SUPPLY (PST) CONTRACTOR	87
4.1.9	INTERFACES WITH RECEIVING SUBSTATION (RSS) CONTRACTOR	91

4.1.10	INTERFACES WITH PLATFORM SCREEN DOORS / GATES (PSD/PSG) CONTRACTOR	92
4.1.11	INTERFACES WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR	92
4.1.12	INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR	94
4.1.13	INTERFACE WITH ESCALATOR CONTRACTOR	94
4.1.14	INTERFACES WITH TRACKWORK (TRW) CONTRACTOR	94
4.1.15	INTERFACES WITH M&P CONTRACTOR	96
4.1.16	INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	98
5.0	ELEVATED E&M (VIADUCT & STATION) CONTRACTORS' INTERFACES	100
5.1.1	INTERFACES WITH ELEVATED CIVIL (VIADUCT & STATIONS) CONTRACTOR	100
5.1.2	INTERFACE WITH ELEVATED STATIONS FINISHING CONTRACTOR	100
5.1.3	INTERFACE WITH SIGNALING & TRAIN CONTROL (S&TC) CONTRACTOR	102
5.1.4	INTERFACE WITH TELECOMMUNICATION (TEL) CONTRACTOR	104
5.1.5	INTERFACES WITH POWER SUPPLY & TRACTION (PST) CONTRACTORS	107
5.1.6	INTERFACE WITH PSD/PSG CONTRACTOR	112
5.1.7	INTERFACE WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR	114
5.1.8	INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR	115
5.1.9	INTERFACE WITH ESCALATOR CONTRACTOR	116
5.1.10	INTERFACE WITH SIGNAGE CONTRACTOR	118
5.1.11	INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	118
6.0	UNDERGROUND E&M CONTRACTORS INTERFACES	121
6.1.1	INTERFACES WITH UG CIVIL CONTRACTOR	121
6.1.2	INTERFACE WITH UG STATIONS FINISHING CONTRACTOR	121
6.1.3	INTERFACE WITH SIGNALING & TRAIN CONTROL (S&TC) CONTRACTOR	122
6.1.4	INTERFACE WITH TELECOMMUNICATION (TEL) CONTRACTOR	124
6.1.5	INTERFACES WITH POWER SUPPLY & TRACTION CONTRACTORS	127
6.1.6	INTERFACE WITH PSD/PSG CONTRACTOR	131
6.1.7	INTERFACE WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR	131
6.1.8	INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR	131
6.1.9	INTERFACE WITH ESCALATOR CONTRACTOR	131
6.1.10	INTERFACE WITH TVS CONTRACTOR	131
6.1.11	INTERFACE WITH ECS CONTRACTOR	133
6.1.12	INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	134
7.0	DEPOT E&M CONTRACTORS INTERFACES	135
7.1.1	INTERFACES WITH DEPOT CIVIL CONTRACTOR	135
7.1.2	INTERFACE WITH DEPOT FINISHING CONTRACTOR	135
7.1.3	INTERFACES WITH SIGNALING & TRAIN CONTROL (S&TC) CONTRACTOR	136
7.1.4	INTERFACES WITH ROLLING STOCK CONTRACTOR	138
7.1.5	INTERFACES WITH TELECOMMUNICATION (TEL) CONTRACTOR	139
7.1.6	INTERFACES WITH POWER SUPPLY AND TRACTION (PST) CONTRACTOR	142
7.1.7	INTERFACES WITH RECEIVING SUBSTATION (RSS) CONTRACTOR	146
7.1.8	INTERFACES WITH PLATFORM SCREEN DOORS / GATES (PSD/PSG) CONTRACTOR	147
7.1.9	INTERFACES WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR	147

7.1.10	INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR	149
7.1.11	INTERFACE WITH ESCALATOR CONTRACTOR	149
7.1.12	INTERFACES WITH M&P CONTRACTOR	149
7.1.13	INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	152
8.0	ELEVATED FINISHINGWORKS CONTRACTORS' INTERFACES	153
8.1.1	INTERFACE WITH ELEVATED CIVIL WORKS CONTRACTOR	153
8.1.2	INTERFACE WITH ELEVATED E&M CONTRACTOR	153
8.1.3	INTERFACE WITH SIGNALING & TRAIN CONTROL (S&TC) CONTRACTOR	153
8.1.4	INTERFACE WITH TELECOMMUNICATION (TEL) CONTRACTOR	154
8.1.5	INTERFACES WITH POWER SUPPLY CONTRACTORS	155
8.1.6	INTERFACE WITH PSD/PSG CONTRACTOR	158
8.1.7	INTERFACE WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR	158
8.1.8	INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR	159
8.1.9	INTERFACE WITH ESCALATOR CONTRACTOR	160
8.1.10	INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	161
9.0	UNDERGROUND FINISHING WORKS CONTRACTORS' INTERFACES	162
9.1.1	INTERFACE WITH UG CIVIL CONTRACTOR	162
9.1.2	INTERFACE WITH UG E&M CONTRACTOR	162
9.1.3	INTERFACE WITH SIGNALING & TRAIN CONTROL (S&TC) CONTRACTOR	162
9.1.4	INTERFACE WITH TELECOMMUNICATION (TEL) CONTRACTOR	162
9.1.5	INTERFACES WITH POWER SUPPLY CONTRACTORS	162
9.1.6	INTERFACE WITH PSD/PSG CONTRACTOR	162
9.1.7	INTERFACE WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR	162
9.1.8	INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR	163
9.1.9	INTERFACE WITH ESCALATOR CONTRACTOR	163
9.1.10	INTERFACE WITH TVS CONTRACTOR	163
9.1.11	INTERFACE WITH ECS CONTRACTOR	164
9.1.12	INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	165
10.0	DEPOT FINISHING WORKS CONTRACTORS' INTERFACES	166
10.1.1	INTERFACE WITH DEPOT CIVIL CONTRACTOR	166
10.1.2	INTERFACE WITH UG E&M CONTRACTOR	166
10.1.3	INTERFACE WITH SIGNALING & TRAIN CONTROL (S&TC) CONTRACTOR	166
10.1.4	INTERFACE WITH ROLLING STOCK CONTRACTOR	167
10.1.5	INTERFACE WITH TELECOMMUNICATION (TEL) CONTRACTOR	167
10.1.6	INTERFACES WITH POWER SUPPLY CONTRACTORS	168
10.1.7	INTERFACE WITH PSD/PSG CONTRACTOR	168
10.1.8	INTERFACE WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR	168
10.1.9	INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR	168
10.1.10	INTERFACE WITH ESCALATOR CONTRACTOR	169
10.1.11	INTERFACE WITH M&P CONTRACTOR	169
10.1.12	INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	169
11.0	SIGNALING & TRAIN CONTROL (S&TC) SYSTEM INTERFACES	170
11.1.1	INTERFACES WITH ELEVATED CIVIL CONTRACTORS	170
11.1.2	INTERFACES WITH UNDERGROUND CIVIL CONTRACTORS	170
11.1.3	INTERFACES WITH DEPOT CIVIL CONTRACTORS	170

11.1.4	INTERFACES WITH ELEVATED E&M CONTRACTORS	170
11.1.5	INTERFACES WITH UNDERGROUND E&M CONTRACTORS	170
11.1.6	INTERFACES WITH DEPOT E&M CONTRACTORS	170
11.1.7	INTERFACES WITH ELEVATED FINISHING WORKS CONTRACTORS	170
11.1.8	INTERFACES WITH UNDERGROUND FINISHING WORKS CONTRACTORS	170
11.1.9	INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS	170
11.1.10	INTERFACES WITH ROLLING STOCK (RS) CONTRACTOR (DTG SIGNALLING SYSTEM)	170
11.1.11	INTERFACES BETWEEN ROLLING STOCK AND SIGNALLING & TRAIN CONTROL CONTRACTORS (CBTC SIGNALLING SYSTEM)	184
11.12	INTERFACES WITH TELECOM CONTRACTOR	223
11.14	INTERFACES WITH PSD/PSG CONTRACTOR	231
11.15	INTERFACES WITH AFC CONTRACTOR	234
11.16	INTERFACES WITH TRACK CONTRACTOR	235
11.17	INTERFACE WITH TVS CONTRACTOR	237
11.1	INTERFACE WITH ECS CONTRACTOR	239
11.19	INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	240
11.20	INTERFACE WITH AUTO WASH PLANT CONTRACTORS	240
12.0	ROLLING STOCK INTERFACES	244
12.1.1	INTERFACES WITH ELEVATED CIVIL CONTRACTORS	244
12.1.2	INTERFACES WITH UG CIVIL CONTRACTORS	244
12.1.3	INTERFACES WITH DEPOT CIVIL CONTRACTORS	244
12.1.4	INTERFACES WITH DEPOT E&M CONTRACTORS	244
12.1.5	INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS	244
12.1.6	INTERFACES WITH S&TC CONTRACTOR	244
12.1.7	INTERFACES WITH TELECOM CONTRACTOR (EXTENSION CORRIDORS)	244
12.1.8	INTERFACES WITH TELECOM CONTRACTOR (NEW LINES)	251
12.1.9	INTERFACES WITH POWER SUPPLY & TRACTION (PST) CONTRACTOR	258
12.1.10	INTERFACES WITH PSD CONTRACTOR	260
12.1.11	INTERFACES WITH TRACK WORK (TRW) CONTRACTOR	262
12.1.12	INTERFACES WITH M&P CONTRACTOR	264
12.1.13	INTERFACE WITH TVS CONTRACTOR	266
12.1.14	INTERFACE WITH ECS CONTRACTOR	267
12.1.15	INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	268
13.0	TELECOM SYSTEM INTERFACES	270
13.1.1	INTERFACES WITH ELEVATED CIVIL CONTRACTORS	270
13.1.2	INTERFACES WITH UG CIVIL CONTRACTORS	270
13.1.3	INTERFACES WITH DEPOT CIVIL CONTRACTORS	270
13.1.4	INTERFACES WITH ELEVATED E&M CONTRACTORS	270
13.1.5	INTERFACES WITH UG E&M CONTRACTORS	270
13.1.6	INTERFACES WITH DEPOT E&M CONTRACTORS	270
13.1.7	INTERFACES WITH ELEVATED FINISHING WORKS CONTRACTORS	270
13.1.8	INTERFACES WITH UG FINISHING WORKS CONTRACTORS	270
13.1.9	INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS	270
13.1.10	INTERFACES WITH S&TC CONTRACTOR	271
13.1.11	INTERFACES WITH RS CONTRACTOR	271
13.1.12	INTERFACES WITH PST CONTRACTOR	271
13.1.13	INTERFACES WITH RECEIVING SUBSTATION (RSS) CONTRACTOR	273

13.1.14 INTERFACES WITH AFC CONTRACTOR	273
13.1.15 INTERFACES WITH LIFT & ESCALATOR CONTRACTORS	275
13.1.16 INTERFACES WITH TRACK CONTRACTORS	275
13.1.17 INTERFACE WITH TVS CONTRACTOR	276
13.1.18 INTERFACE WITH ECS CONTRACTOR	279
13.1.19 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	280
13.1.20 INTERFACE WITH PSD/PSG CONTRACTOR	280
14.0 POWER SUPPLY SYSTEM INTERFACES.....	283
14.1.1 INTERFACES WITH ELEVATED CIVILCONTRACTORS	283
14.1.2 INTERFACES WITH UG CIVIL CONTRACTORS	283
14.1.3 INTERFACES WITH DEPOT CIVIL CONTRACTORS	283
14.1.4 INTERFACES WITH ELEVATED E&MCONTRACTORS	283
14.1.5 INTERFACES WITH UG E&M CONTRACTORS	283
14.1.6 INTERFACES WITH DEPOT E&MCONTRACTORS	283
14.1.7 INTERFACES WITH ELEVATED FINISHING WORKSCONTRACTORS	283
14.1.8 INTERFACES WITH UG FINISHING WORKS CONTRACTORS	283
14.1.9 INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS	283
14.1.10 INTERFACES WITH S&TC CONTRACTOR	284
14.1.11 INTERFACES WITH RS CONTRACTOR	284
14.1.12 INTERFACES WITH TELECOM CONTRACTOR	284
14.1.13 INTERFACES WITH RECEIVING SUBSTATION (RSS) CONTRACTOR	284
14.1.14 INTERFACES WITH TRACK WORK (TRW) CONTRACTOR	288
14.1.15 INTERFACES WITH M&P CONTRACTOR	290
14.1.16 INTERFACE WITH TVS CONTRACTOR	291
14.1.17 INTERFACE WITH ECS CONTRACTOR	291
14.1.18 INTERFACE WITH PSD/PSG CONTRACTOR	291
14.1.19 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	292
15.0 RSS CONTRACTOR'S INTERFACES	293
15.1.1 INTERFACES WITH DEPOT CIVIL CONTRACTORS	293
15.1.2 INTERFACES WITH DEPOT E&M CONTRACTORS	293
15.1.3 INTERFACES WITH TELECOM CONTRACTORS	293
15.1.4 INTERFACES WITH PST CONTRACTORS	293
15.1.5 INTERFACES WITH TRACTION DDC	293
15.1.6 INTERFACES WITH GOVERNMENT AGENCIES	293
15.1.7 INTERFACE WITH POWER SUPPLY AUTHORITIES	294
15.1.8 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	295
16.0 PSD/PSG SYSTEM INTERFACES	296
16.1.1 INTERFACES WITH ELEVATED CIVILCONTRACTORS	296
16.1.2 INTERFACES WITH UG CIVILCONTRACTORS	296
16.1.3 INTERFACES WITH DEPOT CIVILCONTRACTORS	296
16.1.4 INTERFACES WITH ELEVATED E&M CONTRACTORS	296
16.1.5 INTERFACES WITH UG E&M CONTRACTORS	296
16.1.6 INTERFACES WITH DEPOT E&M CONTRACTORS	296
16.1.7 INTERFACES WITH ELEVATED FINISHING WORKS CONTRACTORS	296
16.1.8 INTERFACES WITH UG FINISHING WORKS CONTRACTORS	296
16.1.9 INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS	296
16.1.10 INTERFACES WITH S&TC CONTRACTOR	296

16.1.11 INTERFACES WITH RS CONTRACTOR	296
16.1.12 INTERFACE WITH TVS CONTRACTOR	296
16.1.13 INTERFACE WITH ECS CONTRACTOR	297
16.1.14 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	297
16.1.15 INTERFACE WITH PST CONTRACTORS	297
16.1.16 INTERFACE WITH TELECOM SYSTEM CONTRACTOR	298
17.0 AFC SYSTEM INTERFACES	299
17.1.1 INTERFACES WITH ELEVATED CIVILCONTRACTORS	299
17.1.2 INTERFACES WITH UG CIVILCONTRACTORS	299
17.1.3 INTERFACES WITH DEPOT CIVIL CONTRACTORS	299
17.1.4 INTERFACES WITH ELEVATED E&M CONTRACTORS	299
17.1.5 INTERFACES WITH UG E&M CONTRACTORS	299
17.1.6 INTERFACES WITH DEPOT E&M CONTRACTORS	299
17.1.7 INTERFACES WITH ELEVATED FINISHING WORKS CONTRACTORS	299
17.1.8 INTERFACES WITH UG FINISHING WORKS CONTRACTORS	299
17.1.9 INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS	299
17.1.10 INTERFACES WITH SIGNALLING & TRAIN CONTROL (S&TC) CONTRACTOR	300
17.1.11 INTERFACES WITH TELECOM CONTRACTOR	300
17.1.12 INTERFACE WITH ECS CONTRACTOR	300
17.1.13 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	300
18.0 ELEVATOR (LIFT) INTERFACES	301
18.1.1 INTERFACES WITH ELEVATED CIVILCONTRACTORS	301
18.1.2 INTERFACES WITH UG CIVIL CONTRACTORS	301
18.1.3 INTERFACES WITH DEPOT CIVIL CONTRACTORS	301
18.1.4 INTERFACES WITH ELEVATED E&M CONTRACTORS	301
18.1.5 INTERFACES WITH UG E&M CONTRACTORS	301
18.1.6 INTERFACES WITH DEPOT E&M CONTRACTORS	301
18.1.7 INTERFACES WITH ELEVATED FINISHING WORKS CONTRACTORS	301
18.1.8 INTERFACES WITH UG FINISHING WORKS CONTRACTORS	301
18.1.9 INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS	301
18.1.10 INTERFACES WITH TELECOM CONTRACTOR	302
18.1.11 INTERFACE WITH ECS CONTRACTOR	302
18.1.12 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	302
19.0 ESCALATORS INTERFACES	303
19.1.1 INTERFACES WITH ELEVATED CIVIL CONTRACTORS	303
19.1.2 INTERFACES WITH UG CIVILCONTRACTORS	303
19.1.3 INTERFACES WITH DEPOT CIVIL CONTRACTORS	303
19.1.4 INTERFACES WITH ELEVATED E&M CONTRACTORS	303
19.1.5 INTERFACES WITH UG E&M CONTRACTORS	303
19.1.6 INTERFACES WITH DEPOT E&M CONTRACTORS	303
19.1.7 INTERFACES WITH ELEVATED FINISHING WORKS CONTRACTORS	303
19.1.8 INTERFACES WITH UG FINISHING WORKS CONTRACTORS	303
19.1.9 INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS	303
19.1.10 INTERFACES WITH TELECOM CONTRACTOR	304
19.1.11 INTERFACE WITH ECS CONTRACTOR	304
19.1.12 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	304
20.0 TRACK SYSTEM INTERFACES	305

20.1.1	INTERFACES WITH ELEVATED CIVIL CONTRACTORS	305
20.1.2	INTERFACES WITH UG CIVIL CONTRACTORS	305
20.1.3	INTERFACES WITH DEPOT CIVIL CONTRACTORS	305
20.1.4	INTERFACES WITH SIGNALLING & TRAIN CONTROL (S&TC) CONTRACTOR	305
20.1.5	INTERFACES WITH ROLLING STOCK CONTRACTOR	305
20.1.6	INTERFACES WITH TELECOM CONTRACTOR	305
20.1.7	INTERFACES WITH POWER SUPPLY & TRACTION (PST) CONTRACTOR	305
20.1.8	INTERFACES WITH M&P CONTRACTOR	305
20.1.9	INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	307
21.0	M&P CONTRACTORS' INTERFACES	308
21.1.1	INTERFACES WITH DEPOT CIVIL CONTRACTORS	308
21.1.2	INTERFACES WITH DEPOT E&M CONTRACTORS	308
21.1.3	INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS	308
21.1.4	INTERFACES WITH ROLLING STOCK CONTRACTOR	308
21.1.5	INTERFACES WITH POWER SUPPLY & TRACTION (PST) CONTRACTORS	308
21.1.6	INTERFACES WITH TRACK WORK (TRW) CONTRACTOR	308
21.1.7	INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	308
21.1.8	INTERFACE WITH SIGNALLING & TRAIN CONTROL (S&TC) CONTRACTORS	308
22.0	TVS CONTRACTOR'S INTERFACES	309
22.1.1	INTERFACES WITH UG CIVIL CONTRACTORS	309
22.1.2	INTERFACES WITH UG E&M CONTRACTORS	309
22.1.3	INTERFACES WITH UG FINISHING WORKS CONTRACTORS	309
22.1.4	INTERFACES WITH SIGNALLING & TRAIN CONTROL (S&TC) CONTRACTORS	309
22.1.5	INTERFACES WITH ROLLING STOCK CONTRACTORS	309
22.1.6	INTERFACES WITH TELECOM CONTRACTORS	309
22.1.7	INTERFACES WITH POWER SUPPLY & TRACTION (PST) CONTRACTORS	309
22.1.8	INTERFACES WITH PSD/PSG CONTRACTORS	309
22.1.9	INTERFACES WITH ESCALATOR CONTRACTOR	309
22.1.10	INTERFACE WITH ECS CONTRACTOR	310
22.1.11	INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	311
23.0	ECS CONTRACTOR'S INTERFACES	312
23.1.1	INTERFACES WITH UG CIVIL CONTRACTORS	312
23.1.2	INTERFACES WITH UG E&M CONTRACTORS	312
23.1.3	INTERFACES WITH UG FINISHING WORKS CONTRACTORS	312
23.1.4	INTERFACES WITH SIGNALLING & TRAIN CONTROL (S&TC) CONTRACTORS	312
23.1.5	INTERFACES WITH ROLLING STOCK CONTRACTORS	312
23.1.6	INTERFACES WITH TELECOM CONTRACTORS	312
23.1.7	INTERFACES WITH POWER SUPPLY & TRACTION (PST) CONTRACTORS	312
23.1.8	INTERFACES WITH PSD/PSG CONTRACTORS	312
23.1.9	INTERFACES WITH AFC CONTRACTORS	312
23.1.10	INTERFACES WITH LIFT CONTRACTORS	312
23.1.11	INTERFACES WITH ESCALATOR CONTRACTOR	312
23.1.12	INTERFACES WITH TVS CONTRACTORS	312
23.1.13	INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR	313
23.1.14	INTERFACE WITH SES CONSULTANT	313
24.0	IT/AMS CONTRACTOR'S INTERFACES	314
24.1.1	INTERFACES WITH ELEVATED CIVIL CONTRACTORS	314

24.1.2	INTERFACES WITH UG CIVILCONTRACTORS	314
24.1.3	INTERFACES WITH DEPOT CIVIL CONTRACTORS	314
24.1.4	INTERFACES WITH ELEVATED E&MCONTRACTORS	314
24.1.5	INTERFACES WITH UG E&M CONTRACTORS	314
24.1.6	INTERFACES WITH DEPOT E&M CONTRACTORS	314
24.1.7	INTERFACES WITH ELEVATED FINISHING CONTRACTORS	314
24.1.8	INTERFACES WITH UGFINISHING	314
24.1.9	INTERFACES WITH DEPOT FINISHING CONTRACTORS	314
24.1.10	INTERFACES WITH S&TCCONTRACTORS	314
24.1.11	INTERFACES WITH ROLLING STOCKCONTRACTORS	314
24.1.12	INTERFACES WITH TELECOMCONTRACTORS	314
24.1.13	INTERFACES WITH PSTCONTRACTORS	314
24.1.14	INTERFACES WITH RSS CONTRACTORS	314
24.1.15	INTERFACES WITH PSDCONTRACTORS	315
24.1.16	INTERFACES WITH AFC CONTRACTORS	315
24.1.17	INTERFACES WITH LIFTCONTRACTORS	315
24.1.18	INTERFACES WITH ESCALATOR CONTRACTOR	315
24.1.19	INTERFACES WITH TRACK CONTRACTOR	315
24.1.20	INTERFACES WITH M&P CONTRACTOR	315
24.1.21	INTERFACE WITH TVS CONTRACTOR	315
24.1.22	INTERFACE WITH ECS CONTRACTOR	315

EMPLOYER'S REQUIREMENTS

DESIGN AND CONSTRUCTION INTERFACE MANAGEMENT

CHAPTER 1

1.0 GENERAL REQUIREMENTS

1.1.1 INTRODUCTION

1.1.2 Contract Packages

1.1.2.1 Bangalore Metro Rail Project Phase 2 comprises the following corridors and depots:

Table 1-1: Phase 2 of Bangalore Metro Rail Project

SN	Corridor	Description	Length (km)	Stations
Extensions				
1	Baiyappanahalli to Whitefield	Extension of Eastern line of Phase-I (all elevated)	15.50	14
2	Mysore Road to Challaghatta	Extension of Western Line of phase-I (all elevated)	6.465	5
3	Nagasandra to BIEC Terminal (Bangalore International Exhibition Centre)	Extension of Northern Line of Phase-I (all elevated)	3.77	3
4	Konanakunte Cross to Anjanapura (up to NICE Road)	Extension of Southern Line of Phase-I (all elevated)	6.29	5
New Lines /Reaches				
5	RV Road Terminal – Bommasandra Line (Reach 5)	New Line with passenger interchange station at RV Road in the Southern Line of Phase-I (all elevated)	18.82	16
6	Gottigere-IIMB-Nagawara (Reach 6 – New North-South line)	New Arterial Line - partly elevated (7.46km) and partly underground (13.79km); passenger interchange station with Reach 5 at Jayadeva hospital station	21.25	18 (6 elevated and 12 UG)
Total			72.095	61

1.1.2.2 For the two new corridors (SN 5 & 6 of the table 1-1) and the extensions, new maintenance depots are planned to cater to the requirements as under:

Table 1-2: Depot details

SN	Corridor	Depot Details	Remarks
1	Baiyappanahalli to Whitefield	1. A new full-fledged Depot at Chellagatta of about 49.34 acres of land, with provisions of Stabling and Inspection lines for approx. 45 nos. 6-car provisions of Stabling trains and 2. A new full-fledged Depot at Whitefield of about 43.42 acres of land with provisions of Stabling and inspection lines for approx. 28 nos for 6-car trains.	The existing Baiyappanahalli Depot will be utilized for stabling and maintenance of new line in Phase-2A & 2B.
2	Mysore Road terminal to Kengeri		

SN	Corridor	Depot Details	Remarks
3	Nagasandra to BIEC	A satellite terminal depot of about 7.14 acres of land with provisions of stabling and inspection lines of approx. 10 nos for 6-car rakes.	The existing Peenya Depot will be used for heavy overhaul of all trains of North-South Corridor including extensions.
4	Yelachenahalli to Anjanapura Township (up to NICE Road)		
5	Gottigere-Nagawara Line	A new full-fledged Depot at Kothanur of about 33.08 acres of land, with a provision of stabling (20 Nos) and inspection lines (3 Nos) for 6-car rakes.	A separate depot shall be planned for maintenance of 23 Nos of 6 car rakes (2-minute headway).
6	RV Road – Bommasandra Line	A new full-fledged Depot at Hebbagodi of about 35.28 acres of land, with a provision of stabling (24 Nos) and inspection lines (3 Nos) for 6-car rakes.	Provision of one stabling / sick line at Oxford College station and 2 stabling rake lines each at Electronic City and RV Road terminal stations

- 1.1.2.3 The project shall be implemented progressively with the expected date of introduction of commercial services as per schedule below:

Table 1-3: Phasing of Commissioning

SN	Section	Expected Date of introduction of commercial services [Revenue Operation Date / ROD]

- 1.1.2.4 The following Contract packages are foreseen for implementation of the Bangalore Metro Rail Project Phase 2:

Table 1-4: Phase 2 packages

SN	Package	Package No.	Related designation in this Document
1	Civil viaduct & station Contracts		Elevated Civil
2	Underground tunnel & station Contracts		UG Civil
3	Depot Civil works packages		Depot Civil
4	Elevated Stations E&M Contracts		Elevated E&M
5	Underground E&M Contracts		UG E&M
6	Depot E&M works packages		Depot E&M
7	Elevated Stations Finishing Contracts		
8	Underground Finishing Contracts		
9	Depot Finishing works packages		
10	Signaling & Train Control system package		S&TC or SIG
11	Rolling Stock package		RS
12	Telecom Package		TEL
13	Traction & power supply package		PST (Traction)
14	Receiving Substation package		RSS
15	Platform screen door package		PSD/PSG

SN	Package	Package No.	Related designation in this Document
16	Automatic Fare Collection system package		AFC
17	Lift package		Lift
18	Escalator package		Escalator
19	Trackwork package		TRW
20	Depot M&P package		M&P
21	Tunnel Ventilation system		TVS
22	Environmental control system		ECS
23	IT/AMS package		IT/AMS

Note 1: BMRCL engages Detailed Design Consultants (DDC) for Civil/System works depending on certain context. In other situations, Design & Build (D&B) packages are awarded by BMRCL. The design related interfaces as described in this document, as such, shall be undertaken by relevant Contractors with either DDC or D&B as the context requires.

2: Some of the packages as mentioned above may be clubbed / combined by BMRCL. Under such situations, the interfaces shall be managed accordingly by the relevant interfacing Contractors.

- 1.1.2.5 This document defines the general interface & coordination process requirements as well as specific interface requirements among various interfacing Contractors. The requirements of this document are applicable to all system packages as relevant.

1.1.3 General Interface Requirements

- 1.1.3.1 Interface and co-ordination of the Works will include the co-ordination of all design, technical and programming matters among the various Interfacing Contractors to achieve fully coordinated construction and installation of the facilities.

- 1.1.3.2 This document describes the Contractors responsibilities with regard to interface management and coordination with other Interfacing Contractors responsible for undertaking work that interfaces with the other Contracts. The Contractors' responsibility for interface coordination shall include currently defined Interfacing Contractors and those who may be identified in the future. This responsibility is not limited to a particular number of Interfacing Contractors.

- 1.1.3.3 The Contractors' responsibility for interface co-ordination shall include identification of Interfacing Contractors and those who may be subsequently identified during the course of the Contract for whom the Contractors will need to interface and coordinate the Works. This in no way detracts from the fact that the respective Contractors remain solely responsible for identifying, liaising, and coordinating with all Interfacing Contractors in relation to the Works.

- 1.1.3.4 The Employer's representative will monitor and oversee the interface management activities by the Contractors and will provide direction or information in the following circumstances.

- When the Interfacing Contracts have not yet been awarded.
- When common agreement cannot be reached in a reasonable period between the interfacing parties
- When it is in the interest of the project programme, quality or safety to issue direction.

Direction or information provided by the Employer's Representative wherever necessary, shall not in any way relieve the respective Contractors of their full responsibility to ensure the correctness, accuracy and suitability of the interface implementation and required specification.

- 1.1.3.5 The Contractors shall at all times use their best endeavors to resolve all interfaces applicable to the respective Contract and shall be proactive in seeking out interface issues and their solutions.

- 1.1.3.6 The Contractors shall ensure that all of the above Interface requirements are included in their Interface Management Plan. Figure 1 gives a schematic presentation of the Interface Communication and Coordination processes between the various role- players in the Project.
- 1.1.3.7 The requirements specified herein are by no means exhaustive and it remains the Contractors responsibilities to develop and execute jointly an Interface Plan after the commencement of the activities/works throughout the execution of Contract to ensure that:
- all interfacing issues between the two Contracts are satisfactorily resolved;
 - supply, installation and testing of equipment and software are fully co-ordinated; and
 - that all equipment supplied under the Contracts are fully compatible with each other, whilst meeting the requirements of the respective Specifications.
- 1.1.3.8 The Contractors internal sub-contractors and suppliers' interfaces are the sole responsibility of the respective Contractor and are not covered in this document. However, the respective Contractors shall co-ordinate and manage these interfaces in such a way as to identify and cater for the requirements of the Interfacing Contractors and domestic interfaces, including but not limited to, the avoidance of clashes and sequencing of Works. The Contractors shall compile an internal Interface Management Plan (IMP) for their own use, a copy of which shall be furnished to the Employer's Representative.

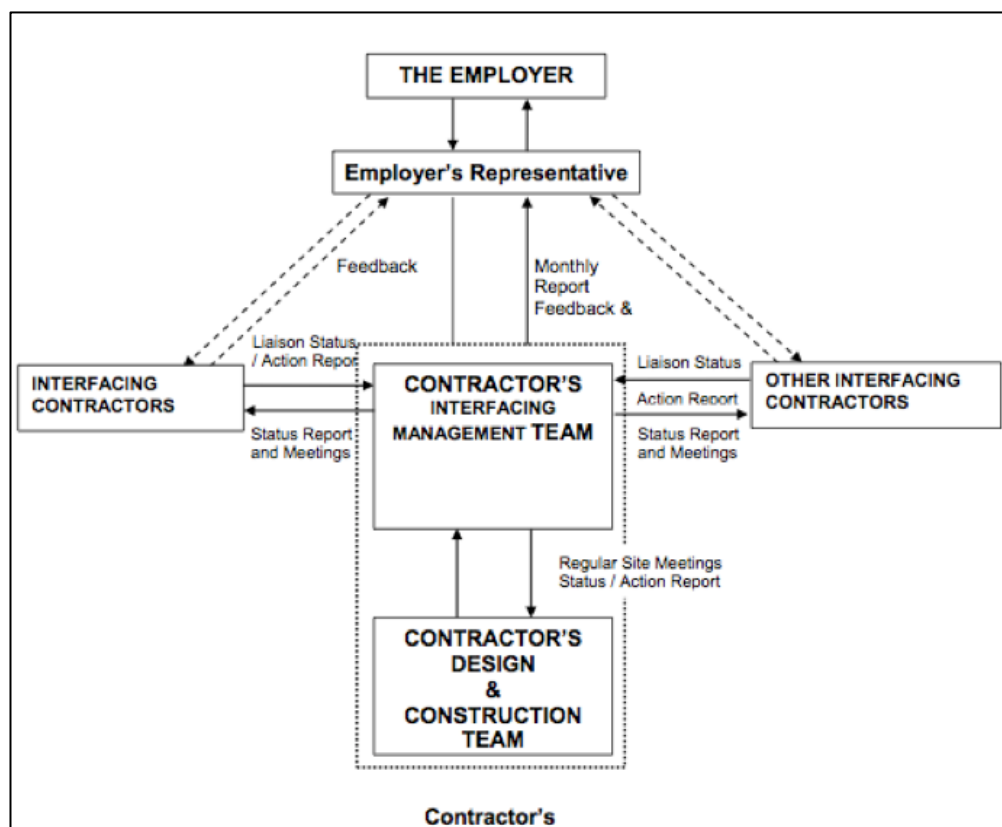


Figure 1: Interface Communication and Coordination Model

1.2 CO-ORDINATION

1.2.1 Contractors' Co-Ordination Responsibilities

The Contractors shall co-ordinate with the Employer's Representative and may be required to attend meetings on issues appertaining to Government authorities and utility agencies regarding the services/facilities to be provided by them for the project.

The Contractors shall ensure that the work of all Interfacing Contractors can be carried out in accordance with the Interface Management Plan prepared by the Contractor.

1.2.2 Site Co-Ordination & Attendance

- 1.2.2.1 The Contractor shall, at their own cost, provide all attendance on and co-ordination with Interfacing Contractors. The following items are not a comprehensive or exhaustive list of the co-ordination or interface attendance items to be provided for the Interfacing Contractors' use, but are intended to provide an outline of the content of amenities, services and facilities for which the Contractor is responsible:
- a) Single point of contact for meetings, actions, planning, scheduling and coordinating.
 - b) Site access
The Contractors shall co-ordinate with the Interfacing Contractors and provide access and use of temporary access roads to and from and within the Site. The Contractor shall co-ordinate all vehicle movements, deliveries and other activities with the Interfacing Contractors so as to ensure conflicts of use will be controlled on and around the Site.
 - c) Storage and Accommodation area
The Interfacing Contractors will require limited temporary site accommodation and storage areas. The Contractors shall agree with the Interfacing Contractors access and areas for storage and temporary site accommodation prior to their commencing work on Site.
 - d) Work space requirement and sequence of Works
 - e) Shared use of Contractors scaffold
Interfacing Contractors shall make their own arrangements for scaffolding, ladders, hoists etc. for their activity. Notwithstanding this requirement, the Contractor(s) shall at all times remain responsible for the management of safety and the maintenance of such scaffolding, ladders and landings. The Contractor(s) will not be required to adapt or erect access scaffolds specifically for the use of Interfacing Contractors.
If the Interfacing Contractor(s) erects and uses his/their own scaffold he/they will be required to adhere to the Contractors' safety rules and access routing for equipment and materials. Interfacing Contractors shall be solely responsible for the safety and maintenance of their scaffolding, ladders and landing etc. Civil Contractors will only inspect and advise about any unsafe practices, which shall be attended by the interfacing Contractors.
 - f) Setting out control points
 - g) Access Openings
The Contractor(s) will form all penetrations and delivery openings and subsequently close them (either temporary or permanent) for access to rooms or areas for the delivery of equipment and materials.
 - h) Temporary power and water supplies shall be provided if available at suitable locations at ground level for the use of Interfacing Contractors. Interface Contractors shall make their own arrangements to extend the same as per their requirements.
 - i) Water tightness: All rooms and areas handed over to Interfacing Contractors shall be in a watertight condition and maintained as such.
 - j) The Interfacing Contractors shall ensure all electrical supplies both temporary and permanent have the correct testing and commissioning certification.
 - k) Interfacing Contractors shall be responsible for disposal of wastage generated by them.
 - l) Interfacing Contractors shall be responsible for repair/restoration of any damage to finishes, walls, floors, ceilings and equipment using polythene, hardboard, steel plates etc. caused by them at their own cost and shall take necessary action to make good to the original condition.
 - m) Programme agreement for mobilizing and demobilizing
 - n) Construction interface co-ordination management of penetrations in structures, embedded and cast-in items, etc.
- 1.2.2.2 The Contractors are deemed to have ascertained for themselves the full scope of their responsibilities and obligations under the Contract in terms of attendance and co-ordination with Interfacing Contractors and shall not be entitled to any additional payment, cost or extension of time for completion, should they fail to do so.
- 1.2.2.3 The Contractors shall make due allowance for providing attendance of personnel, including power and other utility supplies throughout all phases of the Interfacing Contractors work

including testing and commissioning and supplies to Interfacing Contractors that need special consideration during testing and performance trials under peak load conditions.

- 1.2.2.4 Any requirement of core cut shall be checked and initiated in advance for any conduit/cable entry into the station.

1.3 INTERFACE

Co-Ordination of Contractor's Scope of Work

- 1.3.1.1 In accordance with the requirements of the Conditions of Contract and other specified requirements, the Contractor shall co-ordinate his work with that of all Interfacing Contractors and ensure that the design, construction, installation, testing and commissioning requirements of the Interfacing Contractors are incorporated into the Contractor's coordinated plans, programmes and Works. The Contractor shall proactively seek out interface issues and solutions.
- 1.3.1.2 In addition to the Contractor's obligations to the Interfacing Contractors contained elsewhere in the Contract, the Contractor shall provide / handover occupation or access as required to the Interfacing Contractors to those parts of the Works which are subject to Key Dates.
- 1.3.1.3 The Contractor shall complete those portions of the Works that are subject to Key Dates, by the required Key Dates as specified. Those parts of the Works subject to Key Dates shall be completed to a state whereby any Interfacing Contractor can immediately commence his works without the need to make any change, addition or modification to the Contractor's Works.

1.3.2 Interfacing Contractors

- 1.3.2.1 The Interfacing Contractors will be required to not limited to interface and co-ordinate for information, programming, drawings acceptance, handover, etc.
- 1.3.2.2 The Interfacing Contractors have been designated as the Lead Contractor(s) and Participating Contractor. This combined interfacing document has been developed by the Employer, which the Employer may update and/or expand at any time to include additional Interfacing Contractors, and the Contractor's lump sum price for Interface Management shall be deemed to include any such additional works related to interfacing. The leading Interfacing Contractor shall be responsible for administrating, monitoring, managing, supervising and resolving all interface issues and also to any related activities between all Interfacing Contractors.
- 1.3.2.3 In a situation when the Lead Contract has not yet been awarded and the Interfacing Contractor has commenced work, the Employer's Representative will perform the coordination activities including preparation of tentative Interface Specification with the express understanding that they may undergo changes as and when the Lead Contractor commences his work on being awarded the Contract.
- 1.3.2.4 Where an interfacing Contract is yet to be awarded, the Lead Contractor shall proceed with the coordination activities (including preparation of Interface specification) as instructed by the Employer's Representative until such time till the Interfacing Contractor is available with the express understanding that they may undergo changes as and when the interfacing Contractor commences his work on being awarded the Contract.

1.3.3 Interfacing Contractors - Communications and Information Exchange

1.3.3.1 General

- a) The Contractor shall communicate, co-ordinate and exchange information directly with the Interfacing Contractors and the Contractor shall keep the Employer's Representative advised at all times. Information necessary to fulfill the Contractor's interface obligations shall be directly requested and obtained from the Interfacing Parties, and receipt acknowledged. Conversely, the Contractor shall provide directly to the Interfacing Contractors information within the Contractor's scope that is required by them.
- b) All requests for information, acknowledgement of receipt of information, and any official communication between the Contractor and the Interfacing Contractors shall be made in

writing, with a copy to the Employer's Representative (ER) for his information. The Employer's Representative shall be invited to attend all interface meetings between the Contractor and the Interfacing Contractors. Irrespective of whether these meetings were attended by the Employer's Representative or not, the Contractor's monthly progress report to Employer's Representative shall invariably include the details of all interface meetings held and decisions arrived.

- c) The Contractor's programme shall allow time for the availability of necessary interface information from the Interfacing Contractors and in this regard the Contractor shall, where required, proceed on a late start basis to allow adequate time for others to provide required information and thereby achieve design process compatibility.
- d) The Contractor shall allow for the fact that many of the design and construction activities for the different Contracts will be proceeding concurrently. In the event that certain interface information is not forthcoming at the time targeted, the Contractor shall be responsible to resolve the matter with the relevant Interfacing Contractor without recourse to the Employer's Representative, and where necessary develop alternative interim arrangements such that the interface information may be accommodated at a later date.
- e) Definitive dates for transfer of information and particular interface actions shall be confirmed between the Contractor and the Interfacing Contractors.

1.3.3.2 Interfacing Functions

The Interfacing Contractors are responsible for, but not limited to, the following:

- the management of Contract-to-Contract Interfaces as required;<sup>[17]
SEP]</sup>
- preparing the Interface Management Plan and subsequent procedures;
- preparing their Interface Management Programmes in accordance with this procedure and submitting these to the Interfacing Contractors for concurrence;
- preparing the Interface Management Programmes and submitting these to the Employer's Representative for a Notice of No Objection;
- preparing their Interface Coordination Sheets and Interface Specifications and issuing same to the relevant Interface Contractors and Employer's Representative;
- coordinating with the relevant Interface Contractors to establish coordinated Combined Services Drawings (CSD) & Structural E&M (SEM) Drawings;
- maintaining their Interface Specification / Sheets updated continuously and attaching it to their Monthly Progress Report submitted to the Employer's Representative in accordance with the requirements of the Contract and this document.

If any comments or suggestion are stated for compliance, the revised drawings shall be issued both in hard & soft copies to the Employer.

1.3.3.3 Documentation Review

The Contractor shall, as a minimum:

- review those portions of the Specification and Drawings relevant to the interface and transmit such information to the Interfacing Contractors;
- co-ordinate and co-operate with Interfacing Contractors on all Site related matters including but not limited to, Site access and occupation, attendance, safety, verification of work compatibility, survey control, etc.;
- Review the interface information received and agree in writing with the Interfacing Contractors that the interface information is adequate for that stage of that activity.

1.3.3.4 Design Stage ^[17] SEP]

The design interface is an iterative process, thus throughout the design process, the Contractor shall be responsible for coordinating his own design with Interfacing Contractors to develop interface designs in conjunction and co-operation with the designers of Interfacing Contractors.

These interface designs will be monitored and have to be given Notice of no objection by the Employer's Representative, but the Contractor shall work directly with the Interfacing Contractors to develop designs which are compliant to the specification and are mutually acceptable to all parties.

The Contractor shall, immediately upon Contract Award, gather all necessary information and develop his design to a level where meaningful interaction can take place as soon as the Interfacing Contractors are available.

1.3.3.5 Interface Design Change Process

The Contractor shall establish an interface design change process to ensure that:

- All proposed changes for a specific interface are reported, recorded and resolved;
- Proposed changes are fully evaluated; and ^[1]_{SEP}
- Internal/External communications and distribution paths are properly defined

1.3.3.6 Construction Phase

During construction, the Contractor shall, when a construction item is ready for field inspection, advise the Interfacing Contractors in advance to verify compatibility with the needs and requirements of the execution details for the Interfacing Contractors.

The Contractor shall:

- advise the Interfacing Contractors in writing, when the as-constructed interface-related work can be inspected, and provide the necessary Site access and occupation;
- request in writing and obtain from the Interfacing Contractors, interface information required for that stage of the Contract;
- agree in writing with the Interfacing Contractors on the adoption of any applicable comments on the constructed work;
- agree that any testing and commissioning for works can be carried out in accordance with the Interface Management Plan;
- conduct on-Site inspections of the work elements, and give comments in writing to the Interfacing Contractors;
- Agree in writing with the Interfacing Contractors that the as-constructed work substantially meets the interface requirements.
- Where the execution of work by Interfacing Contractors depends upon the Contractor's site management or upon information to be given by the Contractor, the Contractor shall provide the Interfacing Contractors with the required services or the correct and accurate information required to enable the Interfacing Contractors to meet their programme for the construction or installation of their works.

1.3.3.7 Interface Commissioning

The Contractor shall co-ordinate all of his testing and commissioning activities with the Interfacing Contractors. Interface commissioning shall demonstrate that the delivered interface is ready and meets the interface requirements.

Successful completion of all interface commissioning shall prove its readiness for commissioning of the overall Contract scope and completion of the overall Metro-rail Project, prior to handover to the Employer for their commercial operation.

1.3.4 Resolution of Co-Ordination Difficulties

- 1.3.4.1 When the Contractor identifies interface co-ordination difficulties, the Contractor shall review the pertinent points of each Interfacing Contractor to determine possible compatible solutions in terms of sequence, timing and technical details. The Contractor shall then meet with the relevant Interfacing Contractor(s) to determine solutions, which are mutually acceptable to each Interfacing Contractor without diluting the contractual requirements and advise the Employer's Representative.

- 1.3.4.2 Where an acceptable solution has not been identified, the Contractor shall advise the Employer's Representative in writing of the problems encountered. If, in the opinion of the Employer's Representative, an interface is not proceeding satisfactorily, then the Employer's Representative will review the matter, and establish a coordinated plan directing the Contractor and the Interfacing Contractor(s) on the required action. In the event that no agreement can be made between the Contractor and the Interfacing Contractor(s), the Employer's Representative shall determine the requirements to the best of his knowledge, and his determination shall be final and binding on the Contractor and the Interfacing Contractor(s).

1.3.5 Interface Performance

- 1.3.5.1 The Contractor's performance in relation to his compliance with the interface requirements under the Contract shall be assessed by the Employer's Representative 3 months after the Commencement Date and thereafter at three monthly intervals. The assessment will be in the form of an audit of the Contractor's interface management system. This audit will assess the Contractor's compliance with the responsibilities delineated in this document and elsewhere as related to interface management and the preparation of the Interface Management Plan and Programme and other documentation and procedures associated with Interface Management and Coordination.
- 1.3.5.2 The Contractor will be notified of non-conformances from the audit, which will require rectification. Where, in the opinion of the Employer's Representative, the Contractor has failed to rectify a non-conformance within a reasonable period from the date of notification, this may lead to non-payment of any lump sums, until such time as the non-conformance has been rectified to the satisfaction of the Employer's Representative.
- 1.3.5.3 The Contract allows for continuous audits of the Contractor's compliance with his Interface Management Plan and the requirements of this document, and any extreme or continuing failures shall result in a negative audit report, which may lead to non-payment of the relevant payment item in the Preliminaries section (or other relevant section) of the Pricing Document. The decision of the Employer's Representative in this regard shall be final.

1.3.6 CONTRACTOR'S INTERFACE MANAGEMENT SYSTEM

1.3.7 Interface Management System

The Contractor shall establish and maintain an Interface Management System to identify, control and monitor the interfaces of the Contract, which shall include, but not be restricted to, the following:

- Establishment and maintenance of an Interface Management Team suitably qualified and experienced in co-ordination and interface management.
- Provision, as one of his Key Personnel, of a Chief Interface Coordinator, to head the Interface Management Team, suitably qualified and experienced, with the responsibility, experience and authority to resolve interface matters in accordance with the Contract. The Chief Interface Coordinator will develop a monitoring and reporting procedure to be implemented by his team for the duration of the Contract.
- Implement and maintain a strict monitored control of information transfer to the Interfacing Contractors, the Employer and the Employer's Representative utilizing the official channels of communication.
- Provide a comprehensive interface schedule of Interfacing Contractors, including specialist domestic interfaces (i.e., specialist testing and commissioning engineers) identifying all interfacing activities and timetables of events.
- Arrange all internal and external interface meetings. The Employer's Representative may arrange regular meetings to monitor the status of interfaces, and may require special meetings as may be necessary to resolve specific issues. The Contractor's Interface

Management Team will be required to attend such meetings. The Contractor may request assistance from the Employer's Representative to arrange meetings on particular subjects.

- Providing the Employer's Representative with all information and/or details of interfaces, including copies of all correspondence and material.
- Providing the Employer's Representative with access to information for the purpose of conducting audits on the interface system and for confirming that interface co-ordination is proceeding consistently with the Project requirements.
- Establish interface dates for information, documentation, access or works completion requirements.
- Submit method statements of the entire details of the project events.
- The team details to be shared to the Employer with roles & responsibilities.
- Shall indicate details how new interface requirement would be imbibed into the interface management system.
- Maintain at cloud-based database so that all information of the project is accessible to be Employer including all methods statements, drawings and technical documents.

1.3.8 Interface Management Team

The Contractor's Interface Management Team will undertake and fulfill the following tasks:

- Provide timely interface information when requested, anticipating the information needs of the Interfacing Contractors and transmitting such information as soon as it is available.
- Pro-actively keep the Interfacing Contractors informed of any development of the Works related to the interfaces. Communicating and co-operating with the Interfacing Contractors to identify and resolve potential interface problems.
- Advise the Interfacing Contractors on potential problems related to the interfaces, together with proposed solutions likely to be acceptable to Interfacing Contractors and which meet the needs of the Project.
- Arrange and/or attend meetings with the Interfacing Contractors as necessary to resolve interface issues.
- During each stage of the Contract, the Contractor shall directly communicate and co-ordinate with Interfacing Contractors as necessary to achieve a fully co-ordinated construction / installation.
- Contractor shall issue true records of all interface meetings, with appropriate actions and attendance lists, to all Interfacing Contractors, whether in attendance or not, and to the Employer's Representative, within 3 days of the meeting. Minutes of meetings shall be signed by all parties in attendance, signifying their agreement to the contents thereof, before being formally issued by the Contractor.
- All communications shall be marked / copied to the Employer.

The authority and responsibilities of all personnel involved in the Interface Management Team must be clearly defined in the IMP.

1.4 INTERFACE MANAGEMENT PLAN & INTERFACE MANAGEMENT PROGRAMME

1.4.1 General

- 1.4.1.1 The Contractor shall prepare the proposed Interface Management Plan and proposed Interface Management Programme to which the Employer's Representative issues a notice of no objection. The Interface Management Plan and Interface Management Programme shall completely define the Contractor's programme and methodology for interface co-ordination and management, whilst complying with all Key Dates as specified.

- 1.4.1.2 Subsequently, they shall be kept up-to-date and submitted on quarterly basis to the Employer's Representative for scrutiny and notice of no objection and a summary of the principal issues shall be included in each Monthly Progress Report. The Contractor shall note that each submission of these documents is subject to regular audits and the issue of a notice of no objection by the Employer's Representative.

1.4.2 Interface Management Plan (IMP)

The Interface Management Plan is that document which describes the Contractor's interface management in terms of providing a clear description of each of the interfaces, both technically and sequentially, and represents an account of how the Contractor proposes to achieve co-ordination of the Works. The description shall completely detail the Contractor's work scope and interface with each of the Interfacing Contractors in terms of technical description, sequence and timing for each of the elements required to achieve a coordinated design. The Contractor shall demonstrate how potential interface conflicts can be eliminated by design simplification. This document is also required to demonstrate that the coordinated design and construction details described therein fully comply with the needs of others and agreement in writing of these details by the Interfacing Contractors which will be a pre-requisite to the Employer's Representative issuing a notice of no objection.

1.4.3 Requirements for the Interface Management Plan

The Interface Management Plan shall be a process-driven programme in a format to be agreed with the Employer's Representative. The IMP shall incorporate the key activities from both the Interfacing Contractors and Contractor's Works programmes that will enable the Contractor to demonstrate that any Interface is being correctly managed and will result in fully coordinated construction / installation of works.

The Interface Management Plan shall:

- follow the outline structure, numbering system, and related procedures in a format to be agreed with the Employer's Representative.
- be coordinated with the Interfacing Contractors to ensure compatibility of interface identification and definition.
- comply with the Key Dates as specified.
- be transmitted to the Interfacing Contractors concurrently with submittals to the Employer's Representative.
- support the Works Programme to which the Employer's Representative has given a notice of no-objection.
- address each zone of interface i.e. ancillary buildings, train stabling, track work external, track work internal, substations, signaling and telecommunications facilities, operation and control rooms, staff accommodation, external works etc. related to each design submission and stage of design or construction / installation.
- list all relevant interfaces in detail, their status, and the corresponding source(s) of information.
- include interface information transfer dates, which have been agreed by the Interfacing Contractors.
- accommodate comments and inputs required by the Employer's Representative.
- include an account of how the interfaces are being managed.
- identify the latest information regarding agreements with the Interfacing Contractors and transfers of information.
- review and address the design, supply, installation, testing & commissioning programme of the Interfacing Contractors to ensure that the Key Dates of each Contract can be achieved, and highlight any programme risks requiring management attention.
- identify any problems related to co-ordination with Interfacing Contractors.
- identify the sub-systems as well as the civil works and facilities with interfacing requirements;

- define the authority and responsibility of the Contractors and Designated Contractors (and any relevant sub-contractors') staff involved in interface management and development;
- identify the information to be exchanged, precise division of responsibility between the Contractor and Designated Contractors and integrated tests to be performed at each phase of the Contractor's and Designated Contractors' works;
- be fully conforming with the Works Program and shall, in respect of the Contractor and each of the Interface Contractors, show and be in logical agreement with Key Dates and Handover Dates. The IMP shall indicate dates for the commencement and completion of each principal activity by each Contractor, and delivery and installation of principal items of equipment.

1.4.4 Interface Specification

- 1.4.4.1 The Interface Specification and associated drawings shall specify the proposed method and schedule for verifying the interface integrity, the individual equipment/system performance and the combined system performance.

The Interface Specification shall include a programme of tests to demonstrate the performance and integrity of the integrated system. The interface details developed by the Employer's Representative are provided in this Booklet from Chapter 2 onwards. The attached interface details are not final and not limited to and do not relieve the Contractor to identify new interfaces to meet Contract requirements. The interface sheets, which the Contractor shall develop, shall be used as a basis to establish the Interface Specification. Any revision to the Interface Specification shall be mutually agreed between the Contractor and Interfacing Contractors with submission to the Employer's Representative, and shall specifically:

- Understand the design requirements of each party and associated constraints;
- Determine the detailed interface works to be performed during the various stages; and
- Agree on the interface works in reference to respective scope, with any agreements reached to be formally documented in Interface Meeting Minutes, including an actions item list.

The Interface Specification shall ensure that all the construction tolerances at the interface shall meet the requirements of the respective specifications relating to the interface points and shall meet the Contract requirement as a whole.

- 1.4.4.2 The Interface Contractors shall mutually identify and agree the Interfaces that will exist between them using the Interface Coordination Sheets (ICSs). These interfaces may be expanded to include all and any other interfaces that develop during the execution of the Project.

- 1.4.4.3 The Interfacing Contractors shall mutually agree upon the information to be exchanged and shall develop a unique Interface Specification for each interface identified. ^[SEP]
The ICSs will be tracked and monitored using an ICS Register which shall be compiled by the Contractor. This register will track the progress of the ICS from inception to closure and final processing by the Contractor prior to transmittal to the Employer's Representative as a complete Integrated Design. Each interface shall have a unique reference number to enable the Interface to be readily identified and tracked and monitored.

1.5 INTERFACE COORDINATION SHEET (ICS)

- 1.5.1 The Contractor's Interface Coordination sheet, the format of which shall be agreed with Employer's Representative, is required to be used by each of the Interfacing Contractors to record all of the Contract Interfaces. The Contractor shall ensure that each Interfacing Contractor provides input and maintains the ICS continually updated as required.

- 1.5.2 The Contractor shall ensure that the Interfacing Contractors demonstrate their co-ordination efforts as required by the Contract. To achieve this, the Contractor and the Interfacing Contractors shall identify their interface requirements which shall be input into the interface documents, i.e. IMP, ICS, etc. by the Contractor.

- 1.5.3** The Contractor shall monitor the ICS to ensure that, as the Interface progresses, the records show the appropriate status as agreed with the Interfacing Contractors. The Contractor will be responsible for confirming the “Closing Out” of each ICS record, whilst ensuring that throughout the interface process all Interfacing Contractors have agreed to the following: [SEP]
- a) The receiving Interfacing Contractor has received and accepted the Interface being recorded. [SEP]
 - b) All Interfacing Contractors have recorded the interface record as “Proposed Close Out”. [SEP]
 - c) The Confirmation of Co-ordination form has been updated and signed by the relevant Interfacing Contractors.
- 1.5.4** When documents are exchanged for review/comment with Interfacing Contractors, the originator preparing these documents should ensure that they are accompanied by the Confirmation of Coordination. When the Interfacing Contractor returns these documents with comments to the originator, they should be returned with the Confirmation of Coordination form duly completed, confirming coordination and agreement or comment as appropriate, as a record of them having coordinated the interface item. This Confirmation of Co-ordination is to be transmitted to the Employer’s Representative upon signing by the Interfacing Contractor(s).

1.6 COORDINATION DRAWINGS

1.6.1 General

- 1.6.1.1** For the purpose of achieving a Project which is fully coordinated with respect to civil, structural, architectural, building services, electrical, mechanical works and interface elements, and to ensure compatibility between different facilities and services, and adequate space requirements, all drawings are to be reviewed and coordinated by the Contractor.
- 1.6.1.2** The Contractor will provide and issue detailed Interface Working Drawings in terms of items such as; special arrangements, space allocation, cast in items, primary and secondary fixings, grouting of equipment/plinths, drill and fix brackets, embedded and cast-in items and the like.
- 1.6.1.3** The drawings shall be prepared by the Contractor and shall also include composite cross-sections and layouts, which show the spatial requirements of all Interfacing Contractors and identify items to be finalized, defined, or resolved.

1.6.2 Combined Services Drawing (CSDs) And Structural E&M Drawings (SEMs)

- 1.6.2.1** The Contractor’s CSDs and SEMs must be clear and sufficiently detailed to unambiguously show the intent of the subject services and the corresponding structure / facility allowances. While these drawings do not have to duplicate all of the details of the drawings, they must include plans, sections and elevations as required to clearly illustrate the compatible relationship between the different disciplines. Specifically, the drawings will include wall elevation drawings at 1:50 scale (or larger where required) indicating all openings, access panels, reinforcement zones, embedded and cast-in items and the like, and shall be submitted to the Employer’s Representative for a notice of no objection.
- 1.6.2.2** The CSDs shall show the intended locations, routes and spatial relationships of the individual E&M services, Building Services systems, and installations, Depot Equipment, Core Systems installations and other installations, fully coordinated with each other and the civil structural and architectural work. The CSDs shall also clearly indicate that effective cable co-ordination has been achieved in terms of cable location or cable trays and the trunking and cable routing.
- 1.6.2.3** The SEMs shall show all civil, structural, and architectural requirements for the E&M services, Building Services systems and installations, Builder’s works and the Core Systems and other installations.

- 1.6.2.4 Where Builder's works are required by the Interfacing Contractors, the drawings, details, specification notes and catalogue information and the like shall be obtained by the Contractor from these Interfacing Contractors indicating the builder's work to be incorporated into the Works. The Contractor shall include details of such Builder's works in the SEMs and Method Statements as appropriate.
- 1.6.2.5 Builder's work comprises, but is not limited to, the following:
- Construction of plinths, bases, builder's bund walls and the like.
 - placing and fixing of holding down bolts, lifting beams and hooks and other supporting items;
 - supply, fabrication installation, protection, fixing and finishing of supporting steelwork, for equipment and associated accessories;
 - casting in of edgings, angles in recesses, ducts, conduit, pipes etc.;
 - fixing equipment and associated, brackets, cable containment and fixtures;
 - forming of penetrations, sleeves, access panels, holes, chases, recesses, openings;
 - all in accordance with the Contract.
- 1.6.2.6 The CSD/SEMs shall also be used for the purpose of coordinating with the Interfacing Contractors and shall be continuously updated to reflect the latest interface co-ordination. Copies of the CSD/SEM drawings shall be included in submittals to the Employer's Representative.
- 1.6.2.7 Where the CSDs or SEMs do not fully co-ordinate with the site conditions, the Contractor shall co-ordinate and propose a solution to the problem. All proposed solutions shall be issued to the Employer's Representative.
- 1.6.2.8 All drawings of CSD shall be incorporated in BIM model (LOD 400) by the Contractors

1.6.3 Interface Drawings

For the Interface Drawings, the Contractor shall prepare a diagrammatic format for each interface, demarcating of scope of responsibilities between the Contractor and each of the Interfacing Contractors. The Contractor shall submit all drawings with interface requirements for a notice of no objection from the Employer's Representative. Any proposed deviation to the Construction Specification or Drawings shall be identified and justified with design documentation, details and drawings. The submission shall also identify all interface requirements. The pre-design interface drawings are attached respective drawing volume of Bid Documents, it shows general ideas about the interface requirement to the interfacing Contractor. The Contractor should develop own interface drawings with detailed design and dimensions and submit the same to other interfacing Contractor.

1.6.4 As Constructed Drawings

Upon completion of the Works the Contractor shall submit all Combined Services Drawings, and Interface Demarcation Drawings showing the final "As Constructed" status of the Works related to these drawings.

1.7 SPECIFIC INTERFACES AMONG CONTRACTORS

1.7.1 General Requirements

- 1.7.1.1 In these Specifications, unless otherwise stated, the term "Contracts" refers to all the relevant Contracts and the term "Contractors" refers to all the relevant Contractors.
- 1.7.1.2 This document shall be read in conjunction with the relevant paragraphs of the relevant General Specifications and Particular / Technical Specifications. The Contractors shall ensure all requirements of the General Specifications (GS) and Particular / Technical Specifications PS/TS pertaining to the Contracts are fully resolved and implemented.
- 1.7.1.3 The Contractors shall ensure that all requirements of the Specification pertaining to interfaces are properly satisfied.

- 1.7.1.4 The requirements specified herein are by no means exhaustive and it remains the responsibility of the respective Contractors to develop and submit interface plan before execution of the work to ensure that:
- (i) All interface issues between the Contracts are satisfactorily resolved
 - (ii) Supply, installation and testing of equipment and software are fully coordinated
 - (iii) All equipment supplied in the Contracts are fully compatible with each other

- 1.7.1.5 In the event of a conflict between the Particular / Technical Specifications and this specification/document, the requirements of the Particular / Technical Specifications shall prevail.

1.7.2 Interface Management

- 1.7.2.1 Each Contractor shall establish a structured process to integrate with other systems to ensure safe, reliable and efficient operations under both normal and degraded conditions to the satisfaction of the Employer / Engineer.
- 1.7.2.2 The Contractors shall ensure that all the requirements of the Metro Railway General Rules and other statutory requirements are duly met by incorporating necessary interfaces and design requirements.
- 1.7.2.3 Each Contractor shall ensure that the equipment supplied under the respective Contract are properly interfaced and integrated with other systems.
- 1.7.2.4 Each Contractor shall appoint competent and experienced person (Interface Manager) with not less than 5 years of Metro rail/ Railway project experience who shall be a single point of contact for all interface design and testing works with the interfacing Contractors and the Employer / Engineer.
Full time mobilization of 'Interface Manager (IM)' at site shall be done by the Contractor within three (3) months of the commencement date. Non-mobilization of the 'Interface Manager (IM)' within the stipulated three months would attract penalty (to be solely finalized by the Engineer) for delay of each month or part thereof. The penalty amount shall include the consequential loss on account of non-availability of an approved and experienced 'Interface Manager (IM)'.
- 1.7.2.5 Each Contractor shall be responsible for interface identification, establishment, construction and testing works either in the capacity as the Lead Contractor or Participating Contractor.
- 1.7.2.6 The Lead Contractor will be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors all the required interfaces and interface design documents and interface progress reports for submission to the Engineer for acceptance. The Lead Contractor will also prepare and issue all interface meeting minutes after incorporating Participating Contractors' comments within 3 days of the meeting and provide bi weekly interface progress reports to all the participating Contractors for information.
Later, forwarding of issued minutes of meeting and bi weekly interface progress reports to respective Engineers shall be responsibility of concerned Contractors.
All the Participating Contractors shall ensure that copy of the Interface design documents submitted to the Engineer of the Lead Contractor shall also be submitted to their respective Engineer required to participate in the Interface Meetings.
- 1.7.2.7 The participating Contractors shall collaborate fully with the Lead Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.
- 1.7.2.8 The costs for all interface design and testing works shall be deemed to be included in the Contract sum regardless of the actual extent of effort required or expended by the Contractors.
- 1.7.2.9 The Contractors shall be fully responsible for the management and control of its subcontractors in relation to all interfacing activities carried out under the Contract.

- 1.7.2.10 If there is revision in stipulations given in the Contracts due to external agency requirements, revised interface will continue to be carried out without disturbing the project schedule. Any modification and/or changes in contractual matters shall be dealt separately.

1.7.3 Lead and participating Contractors

The table below describes the Lead and Participating Contractors:

BMRCL Interface Matrix

based on "PROJECT WIDE INTERFACE DOCUMENT - COMMON BOOKLET FOR ALL PACKAGES" Nov 2021

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
		Civil (Ele)	Civil (UG)	Civil (Depot)	E&M (Ele)	E&M (UG)	E&M (Depot)	Finishing (Ele)	Finishing (UG)	Finishing (Depot)	S&TC	RS	Tel	PST	PSD	AFC	Lift	Escalator	Track	M&P	TVS	ECS	IT/AMS	RSS
1	Civil (Ele)				2.3			2.4			2.5	2.6	2.7	2.8	2.9	2.10	2.11	2.12	2.13				2.14	
2	Civil (UG)					3.3			3.4		3.5	3.6	3.7	3.8	3.9	3.10	3.11	3.12	3.13		3.14	3.15	3.16	
3	Civil (Depot)						4.4			4.4	4.5	4.6	4.7	4.8	4.10	4.11	4.12	4.13	4.14	4.15			4.16	4.9
4	E&M (Ele)	5.1						5.2			5.3		5.4	5.5	5.6	5.7	5.8	5.9					5.11	
5	E&M (UG)		6.1						6.2		6.3		6.4	6.5	6.6	6.7	6.8	6.9			6.10	6.11	6.12	
6	E&M (Depot)			7.1						7.2	7.3	7.4	7.5	7.6	7.8	7.9	7.10	7.11		7.12			7.13	7.7
7	Finishing (Ele)	8.1			8.2						8.3		8.4	8.5	8.6	8.7	8.8	8.9					8.10	
8	Finishing (UG)		9.1			9.2					9.3		9.4	9.5	9.6	9.7	9.8	9.9			9.10	9.11	9.12	
9	Finishing (Depot)			10.1			10.2				10.3	10.4	10.5	10.6	10.7	10.8	10.9	10.10		10.11			10.12	
10	S&TC	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.8	11.9		11.11	11.12	11.13	11.14	11.15			11.16	11.20	11.17	11.18	11.19	
11	RS	12.1	12.2	12.3			12.4			12.5	12.6		12.7 & 12.8	12.9	12.10				12.11	12.12	12.13	12.14	12.15	
12	Tel	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	13.9	13.10	13.11		13.12	13.20	13.14	13.15	13.15	13.16		13.17	13.18	13.19	13.13
13	PST	14.1	14.2	14.3	14.4	14.5	14.6	14.7	14.8	14.9	14.10	14.11	14.12		14.18				14.14	14.15	14.16	14.17	14.19	14.13
14	PSD	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	16.10	16.11	16.16	16.15							16.12	16.13	16.14	
15	AFC	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	17.9	17.10		17.11									17.12	17.13	
16	Lift	18.1	18.2	18.3	18.4	18.5	18.6	18.7	18.8	18.9			18.10									18.11	18.12	
17	Escalator	19.1	19.2	19.3	19.4	19.5	19.6	19.7	19.8	19.9			19.10								???	19.11	19.12	
18	Track	20.1	20.2	20.3							20.4	20.5	20.6	20.7							20.8			20.9
19	M&P			21.1	-	-	21.2	-	-	21.3	21.8	21.4		21.5	-	-	-	-	21.6				21.7	
20	TVS		22.1			22.2			22.3		22.4	22.5	22.6	22.7	22.8			22.9				22.10	22.11	
21	ECS		23.1			23.2			23.3		23.4	23.5	23.6	23.7	23.8	23.9	23.10	23.11			23.12		23.13	
22	IT/AMS	24.1	24.2	24.3	24.4	24.5	24.6	24.7	24.8	24.9	24.10	24.11	24.12	24.13	24.15	24.16	24.17	24.18	24.19	24.20	24.21	24.22		24.14
23	RSS			15.1			15.2						15.3	15.4									15.8	

	Lead contractor
	Participating contractor
##	Section no. in Project Wide Interface Document
	Newly Added
	Existing Modified

Note

1. The Contractors mentioned above are the lead Contractors, for RS and S&TC interface, Rolling Stock is lead Contractor for Extension lines and S&TC is the lead Contractor for new lines or *If S&TC and Telecom works for the new lines are implemented under the same Contract, then Telecom Contractor shall be the Lead Contractor for the interface between Rolling Stock and Telecom.
2. With respect to interface between Rolling Stock Contractor and other Designated Contractors, Rolling Stock Contractor shall be the Lead Contractor in all cases except for interface with Signaling for all the new lines where Signaling Contractor shall be the Lead Contractor.

CHAPTER 2

2.0 ELEVATED CIVIL (VIADUCT & STATION BUILDING) CONTRACTORS INTERFACES

2.1.1 INTERFACE WITH DESIGNER / DESIGN WING / CONSULTANTS

The Contractor is responsible for coordinating and interfacing with following:

- (i) Detailed Design Consultants if engaged by BMRCL for various reaches / sections
- (ii) In-house Design Wing of BMRCL
- (iii) Agency which BMRCL has engaged for preparation of project DPR
- (iv) Survey agency engaged by BMRCL
- (v) Geo-tech investigating agency engaged by BMRCL
- (vi) Any other design agency / consulting agency engaged by BMRCL which has relevance for Contractor's work

2.1.2 INTERFACE WITH UTILITY AGENCY

The Contractor is responsible for coordinating and interfacing with following agencies:

- (i) BBMP
- (ii) BWSSB
- (iii) BESCOM
- (iv) Other utilities / Civic Agencies
- (v) Karnataka State Fire & Emergency Services
- (vi) Any other Statutory Authorities of Central and State government.

2.1.3 INTERFACE WITH ELEVATED (VIADUCT & STATIONS) E&M CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the Contractors shall include the following minimum but not limited to:

Item No.	Subject	Elevated Civil (Viaduct/Station) Contractor	Elevated E&M Contractor
	Design Stage		
1	Equipment rooms, sumps, conduit and ducts	<ul style="list-style-type: none"> Shall incorporate input from the E&M Contractor and prepare Structural E&M drawings (SEM) that will show all the necessary openings, cut-outs, hatch, core cutting, plinths, foundations etc. 	<ul style="list-style-type: none"> Shall provide design of all E&M equipment, sizing, weight, layouts etc. Shall provide input for deciding room sizes at station to civil Contractor.

Item No.	Subject	Elevated Civil (Viaduct/Station) Contractor	Elevated E&M Contractor
		<ul style="list-style-type: none"> Shall provide input for seepage, sewage and domestic water pipeline etc. for route drawing in stations. Shall review and revise the SEM as and when required. 	<ul style="list-style-type: none"> Shall prepare equipment, cable, raceways, trunking, seepage, sewage, hydrant, and domestic water pipeline etc., route drawing in stations. Shall provide input for SEM drawings and the inputs on requirement of cable shaft, shaft opening details, floor cut-outs, pull pits etc., Shall review SEM
	C&I Stage		
2	Equipment rooms, sumps, conduit and ducts	<ul style="list-style-type: none"> Complete equipment rooms such as ancillary building, sumps and other spaces for the installation of the E&M equipment such as pumps, DGs, control panels etc., Provide structural openings, construction of plinths/foundations, embedded conduits, sleeves for use of E&M Contractor as per SEM. All unused openings of all floor and wall openings shall be closed in co-ordination with E&M Contractor. Shall provide suitable road access for loading/unloading of the equipment. 	<ul style="list-style-type: none"> Shall install E&M equipment as required in the E&M scope of works at location provided by the station Contractor. Shall provide raceways, trunking for the E&M works and other system Contractor for all routes defined in the CSDs. Shall close all floor and wall openings provided by Civil Contractor with fire rated material after installation of all E&M services related to their work. Installation of seepage and sewage pumps along with embedded discharge pipe up to discharge level outlet. (Not for construction activities)
3	Temporary power for installation, testing and commissioning	Shall provide temporary power as per requirement at site.	<ul style="list-style-type: none"> Shall co-ordinate with Civil Contractor for provision of suitable sockets for temporary power. Shall provide suitable electric meters for calculating the consumption. Shall provide required cables and distribution boards for his requirements. Shall pay to Civil Contractor for the power consumption. <p>Note: If temporary power is not available from Civil Contractor, then E&M Contractor shall make his own arrangement</p>
	T&C Stage		
4	Nil		
	O&M Stage		
5	Nil		

2.1.4 INTERFACE WITH ELEVATED STATIONS FINISHING CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Elevated Civil (Viaduct/Stations) Contractor	Elevated Station Finishing Contractor
	Design Stage		
1	Station design including all passenger areas and equipment rooms	Design and coordination with Finishing Contractor	Furnish the requirements related to Finishing Works for incorporation in the designs
	C&I Stage		
2	Station construction including all passenger areas and equipment rooms	Civil and structural construction of the station as per agreed designs duly in coordination with Finishing works Contractors as well as other designated Contractors	Finishing works of the station as per scope of work in coordination with Civil Contractor as well as other designated Contractors
	T&C Stage		
3	Nil		
	O&M Stage		
4	Nil		

2.1.5 INTERFACE WITH SIGNALING & TRAIN CONTROL (S&TC) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Elevated Civil (Viaduct/Station) Contractor	S&TC Contractor
	Design Stage		
1	Layout of rooms at the station: Signalling Equipment room (SER), UPS, Signalling maintenance room, and Station Control Room (SCR).	<ul style="list-style-type: none"> Prepare and furnish station drawings; Incorporate room requirements and trenches in S&T UPS Room, providing cut outs, shafts etc. as given by S&TC Contractor. Provision of space for Emergency Stop Plunger (ESP). 	<ul style="list-style-type: none"> Mark cable trays on the station drawings in close coordination with the DDCs/Civil Contractors. Review design with the DDCs/Civil Contractors. Co-ordinate closely with Elevated Civil Contractor. Design furniture layout for all system workstations in SCRs.
2	Cable support infrastructure along the viaduct and Stations	Shall consider requirements of cable troughs/supports in design	Shall provide the requirement of cable troughs/supports on the GAD/CSD for main cables in close coordination with the civil design and/or construction Contractor.

Item No.	Subject	Elevated Civil (Viaduct/Station) Contractor	S&TC Contractor
3	Track side equipment for Signalling/ Radio Communication system	Shall interface for design requirements and provide the required space for line side equipment	Furnish locations and load etc. of line side equipment.
	C&I Stage		
4	Layout of rooms at the station: Signalling Equipment room (SER), UPS, Signalling maintenance room, and Station control rooms (SCR).	Construct the rooms as per the design, provide cut outs, shafts, false flooring, false ceiling, fire rated doors, cable trenches for S&T UPS Room, checkered plate for cable trench cover in UPS room etc. as required.	<ul style="list-style-type: none"> Provide equipment foundations / pedestals / base frames. Install all S&TC equipment, cables, cable trays under false floors etc. Seal the gaps after cable installation work with fire resistant material.
5	Track side equipment for Signalling/ Radio Communication system	<ul style="list-style-type: none"> Shall construct as per finalized design. Shall facilitate the mounting of trackside Signalling equipment on Viaduct 	<ul style="list-style-type: none"> Install cables for all Signalling systems including provision of all accessories for dressing. Install all line side equipment including equipment foundations etc. Provide cable trays with cover at expansion joints, shielding of cables where necessary. Install all line side equipment including equipment foundation, if any.
	T&C Stage		
6	Nil		
	Maintenance Stage		
7	Nil		

2.1.6 INTERFACE WITH ROLLING STOCK CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	Elevated Civil (Viaduct/Station) Contractor	Rolling Stock Contractor
	Design Stage		
1	Car Details	Shall obtain details of Rolling stock including length of train cars, height and location of doors for station design as per SoD.	Shall furnish required details of Rolling stock including Length of train cars (with front coupler), height and location of doors for station design meeting with the provisions of SoD.
2	Kinematic and structural gauges	Shall obtain details of kinematic and structural gauges from Rolling Stock Contractor and take into account during design to ensure platform and walkway clearance while train is running.	Shall furnish the details of kinematic and structural gauges respective to all speeds.

SN	Subject	Elevated Civil (Viaduct/Station) Contractor	Rolling Stock Contractor
3	Viaduct Design	Shall provide the space proof details to Rolling stock Contractor	Shall coordinate with Viaduct Contractor
4	Design of walkway slab and Emergency Ramp	Walkway slab shall be designed as per SoD and with interaction of System Contractor (RS).	<ul style="list-style-type: none"> Shall study the track geometry including horizontal and vertical profile for the entire project. The project is designed with side evacuation. The Rolling Stock Contractor and Track Contractor shall jointly submit the calculation of horizontal and vertical shift of carbody on inside curve and outside curve in stationary condition and running condition. Shall design the emergency ramps and provide suitable enclosures for housing the ramps inside the train.
C&I Stage			
5	Clearances checking with respect to platform alignment	Shall jointly check and confirm the curves, dimensional clearances, gradients, chainages, levels and emergency escape provision	Shall co-ordinate and confirm with Elevated Civil/Station Contractor.
6	Construction & Installation	Shall participate in test run and perform modifications if required.	Required to conduct test run with one car at low speed in the viaduct sections
T&C Stage			
7	Integrated testing	Shall coordinate with RS Contractor to complete testing and commissioning work	Requires to conduct integrated test with all Systems.
8	Gap measurement at walkway and platform	Shall jointly check and measure the gap between walkway/platform and coach floor and shall rectify the defects noticed.	Shall provide train and jointly check and measure the gap between walkway/platform and coach floor for rectifying the defects noticed
9	Structure gauge checking	Shall jointly measure the various clearances required for structure gauge and shall rectify the defects noticed	Shall provide structure gauge and manpower and jointly support to measure the clearances.
10	KE test	Shall jointly check whether KE infringement is there or not. Shall rectify the defects noticed.	Shall provide the train with KE profile and jointly support the Elevated Civil/Station Contractor.
Maintenance Stage			
11	Nil		

2.1.7 INTERFACE WITH TELECOMMUNICATION (TEL) CONTRACTOR

The Station Contractor(s) and Telecom Contractor shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	Elevated Civil (Viaduct & Station) Contractors	Telecom Contractor
Design Stage			
1	Layout of relevant equipment rooms at the station	<ul style="list-style-type: none"> Shall prepare and furnish station drawings; Shall incorporate room requirements and routing of Cable ducts / cable trays, pedestal / base frames in the designs Shall provide the cutout above the false ceiling, below the false flooring of the TER, SCR, UPS, CDMA rooms as per inputs by Telecom Contractor. 	<ul style="list-style-type: none"> Mark requisite requirements in close coordination with the Elevated Civil design / construction Contractor. Review design with the Elevated Civil design Contractor. Shall mark the cut out in all the rooms for the cable entry. Shall furnish all design of pedestals/ base Frames layouts for all systems rack, etc. in TER (Telecom Equipment Room).
2	Station Control Room / Telecom Equipment Room (TER)	<ul style="list-style-type: none"> Shall incorporate design requirement of Telecom Contractor in the SCR /TER room viz. Space for workstations / and other Telecom equipment etc. Shall incorporate room requirements providing cutouts in the SCR/TER, pipes & chamber of size mm 500*500*400 (W*L*H) in the technical corridor. 	<ul style="list-style-type: none"> Shall furnish layout of Telecom equipment within Station Control Room and Telecom equipment room Shall mark the cable trays, cut outs, pipes & chamber on the station drawings in close coordination with the DDC/Civil Contractors. Shall review the design with the DDC/Civil Contractors. Co-ordinate closely with Station Construction Contractor
3	TETRA Radio Tower	Shall incorporate the requirement of radio tower in stations' design as per the requirement of Telecom Contractor.	Shall provide detailed design requirements for radio tower and shall coordinate appropriately
4	Cable support infrastructure along the viaduct and Stations	Shall consider requirements of cable troughs/supports in design	Shall provide the requirement of cable troughs/supports on the GAD/CSD for main cables in close coordination with the civil design and/or construction Contractor.
5	Track side equipment for Telecom / Radio Communication system	Shall interface for design requirements and provide the required space for line side equipment	Furnish locations and load etc. of line side equipment.
C&I Stage			
6	Layout of relevant equipment rooms at the station	<ul style="list-style-type: none"> Construct the rooms as per design, providing cut outs, shafts etc. as required. Shall coordinate with Telecom Contractor for the pedestals/ base frames marking and the layout of the racks in the TER and provide suitable cutting in the false floor 	<ul style="list-style-type: none"> Provide equipment foundations/ pedestals. Install all telecom equipment, cables etc. Seal the gaps after cable installation work with fire resistant material. Shall install pedestals/ base Frames for all system's racks and coordinate with Civil Contractor
7	Track side equipment for Telecom / Radio Communication system	Shall construct as per design finalized. Shall facilitate the mounting of trackside Telecom equipment on Viaduct	<ul style="list-style-type: none"> Install cables for all Telecom systems including provision of all accessories for dressing. Install all line side equipment including equipment foundations etc.

SN	Subject	Elevated Civil (Viaduct & Station) Contractors	Telecom Contractor
			<ul style="list-style-type: none"> Provide cable trays with cover at expansion joints, shielding of cables where necessary. Install all line side equipment including equipment foundation, if any.
8	Station Control Room / Telecom Equipment Room	Construct the SCR/TER room as per approved design	Shall install telecom equipment's within Station Control Room and Telecom Equipment Room
9	TETRA Radio Tower	<ul style="list-style-type: none"> Shall construct the structure to enable installation of radio tower Tower foundation shall be constructed as per design submitted by Telecom Contractor. 	<ul style="list-style-type: none"> Shall verify the tower foundation jointly with Civil Contractor as per design submitted Shall install the radio towers
10	Construction and Installation	Shall install the mounting and fixing arrangements for heavy equipment like CCTV monitors, display boards, analogue clocks etc., during the construction as per the Telecom Contractor's requirements.	<ul style="list-style-type: none"> The fixtures will be to be designed and installed by Telecom Contractor. Primary Fixtures & Secondary Fixtures for Telecom equipment shall be provided by Telecom Contractor as per aesthetics of the Station architecture. Sample to be get approved from BMRCL.
	T&C Stage		
11	Nil		
	Maintenance Stage		
12	Nil		

2.1.8 INTERFACES WITH POWER SUPPLY & TRACTION (PST) CONTRACTORS

It is necessary to provide cable support infrastructure etc. on the viaduct; therefore, it is essential that close interaction is maintained among the PST Contractor and various Viaduct Contractors. Interfacing will be required for:

- Cable bracket arrangement for carrying power and control cables on Viaduct.
- Providing buried pipes for cables crossing tracks.
- Providing openings in viaduct structure for passing cables etc.
- Providing sockets along the viaduct
- Connection of earth cable, ITL etc. as necessary, to earth plates on parapet, girder segment, piers, etc. and to hand rail, for earthing.
- Providing viaduct lighting fixtures and cable along the viaduct.

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Item Description	Elevated Civil (Viaduct/Station) Contractor	Power Supply & Traction (PST) Contractor
	Design Stage		

Item No.	Item Description	Elevated Civil (Viaduct/Station) Contractor	Power Supply & Traction (PST) Contractor
1	All interface issues related to station building	<ul style="list-style-type: none"> Shall interface with PST Contractor and factor in the relevant requirements in ASS/TSS/station civil/structure designs Shall design adequate ventilation and natural lighting system for ASS/TSS. As far as possible expansion joints on the roof above ASS & ASS/TSS room to be avoided. 	Shall furnish the requirements of: <ul style="list-style-type: none"> ASS/TSS rooms layout design Equipment ingress / egress route requirements Weight and dimension of cables Cable paths (ducts, trays, brackets etc.), gallery size, route alignment, mounting arrangement of cables, bending radii of cables Earthing, bonding and stray current mitigation related requirements ETS related requirements Platform insulation
2	All interface issues related to viaduct	Shall interface with PST Contractor and factor in the relevant requirements in viaduct civil/structure designs	Shall furnish the requirements of: <ul style="list-style-type: none"> Cable path, gallery size, route alignment and mounting requirements requirement for various cables on the viaduct Earthing, bonding and stray current mitigation related requirements Designs / drawings showing arrangement of Earth terminals required to be provided on piers, pedestals, segments, parapet etc. and the extent of welding required to be done on Reinforcement bars Size and locations where the openings / cutouts are required in viaduct structures Way side disconnection switches on viaduct
C&I Stage			
Stations			
3	ASS/TSS Room / Building	<ul style="list-style-type: none"> Shall construct ASS/TSS room / building to be requirement of the PST Contractor As far as possible expansion joints on the roof above ASS & ASS/TSS room to be avoided. Shall design floor for loads as furnished by the PST Contractor Shall provide necessary foundations for transformers, panels, other equipment etc. Shall provide the necessary cutouts for cables entry and exit from track level to the room Loading / unloading platform with lifting hooks to be provided, if possible, as per site condition. Proper 	<ul style="list-style-type: none"> Shall jointly inspect and takeover the ASS/TSS room in coordination with Civil Contractor Shall coordinate Shall coordinate for the room size and other associated requirements Shall furnish the equipment weight and size details to station building Contractor for designing floor for appropriate load Should ensure height of the rolling shutters are adequate for pushing in the tallest equipment

Item No.	Item Description	Elevated Civil (Viaduct/Station) Contractor	Power Supply & Traction (PST) Contractor
		removable / detachable barricade railings for loading & unloading platform to be provided in consultation with PST Contractor <ul style="list-style-type: none"> No emergency stair case should infringe the loading / unloading platform or affect movement of materials 	
4	Installation of 33 kV, 750V dc cables, traction return cables, ETS cable and control cable	<ul style="list-style-type: none"> Shall provide suitable opening and fixing HDPE pipe for carrying cables inside ASS/TSS, for ETS and at track crossings as per requirement. The mounting arrangement of ETS has to be provided in consultation with PST Contractor. Shall take into consideration the bending radius of cable and covering of cables in public places. Station Building Contractor shall provide suitable opening in the TSS/ASS room at appropriate location for raising the cables coming from RSS/TSS at ground to the ASS/TSS by providing a shaft from ground to the TSS/ASS room. 	<ul style="list-style-type: none"> Shall supply & install 33 kV, 750V dc cables, traction return cables, ETS cables, SCADA cables for ETS connection and other cables Shall supply the suitable HDPE Pipes. Shall furnish the detailed cable schedule Shall interface with the Station Contractor for the cable path for 33kV, 750V cables, traction return cables and SCADA cable for ETS connection in the station area Shall co-ordinate with Station Contractors for provision of opening and HDPE pipes of adequate size to carry the cables inside ASS/TSS/ETS. Shall close the opening with fire/water tight EPDM separators after installation of the cables Shall coordinate with Station Building Contractor for suitable opening in the TSS/ASS room at appropriate location for raising the cables coming from RSS/TSS at ground to the ASS/TSS. Shall coordinate with civil Contractor for providing a shaft form ground to the TSS/ASS room.
5	Temporary Power for Installation, testing & commissioning	Shall provide sockets for availing temporary power, at main DC if available, inside ASS/TSS rooms as per requirement	<ul style="list-style-type: none"> Shall co-ordinate with Station Contractor for provision of temporary power Shall provide suitable meters for calculating the consumption Shall advise temporary power demand & required capacity and provide temporary cable Shall install the required DB with all safety features for availing the temporary power Shall pay to the Station Contractor for the power consumption

Item No.	Item Description	Elevated Civil (Viaduct/Station) Contractor	Power Supply & Traction (PST) Contractor
			Note: If temporary power is not available from Station Contractor, then PST Contractor shall make his own arrangement.
6	Installation of Equipment in ASS/TSS	<ul style="list-style-type: none"> Shall construct ASS/TSS rooms keeping in view the specific requirements of PST Contractor regarding passages, ingress / egress routes, door size, knock out panels, floor openings etc. for access of heavy equipment forming permanent works Shall provide cut-outs in floor / roof / walls for cable entry to the requirements of PST Contractor. Shall make provision for passage/crossing of various cables in the station along the walls, under the platform copings etc. for cable entry from viaduct cable duct to ASS/TSS room. Shall provide hatch, gantry beams and loading deck for carrying heavy equipment and materials to substations. Shall provide lifting hooks in ASS/TSS rooms as per requirements of PST Contractor. 	<ul style="list-style-type: none"> Shall provide dimensions and weights of various equipment Shall supply, transport and install ASS/TSS Equipment including Transformers, 33kV Switchgear, Traction Transformers, Rectifiers, HSCB, Distribution Boards etc. as per Specifications. Shall provide equipment layout drawing. Shall provide necessary foundations for transformers, panels other equipment etc. Alternatively, the Contractor can provide suitably designed anchor-fasteners to fix transformers, 33kV panels, Battery chargers etc. to the basic floor/pedestal Shall coordinate with Station Contractors for suitable design of ASS/TSS rooms to ensure smooth passage for carrying the equipment inside ASS/TSS. Shall coordinate with Station Contractors for suitable openings for cable and earthing connections and cable entry from viaduct cable duct to ASS/TSS room. Shall confirm the fire safety provisions Shall arrange material handling equipment at his own cost
7	Earthing, bonding and stray current mitigation arrangements at stations	<ul style="list-style-type: none"> Shall coordinate for requirements of stray current monitoring scheme Shall associate with PST to verify the earthing-bonding of structure as per approved scheme. Shall provide structure earth terminals Shall connect various structures at station to Earth Cable as per schematic 	<ul style="list-style-type: none"> Shall provide schematic arrangement of earthing, bonding and stray current protection management in the stations Shall connect Structure Earth Cable (SEC) to MET in ASS/ ASS+TSS

Item No.	Item Description	Elevated Civil (Viaduct/Station) Contractor	Power Supply & Traction (PST) Contractor
8	Emergency Trip System (ETS) Installation	Shall provide niche in walls of stations or mounting arrangement on the walls/ pillars to accommodate ETS equipment and cables	<ul style="list-style-type: none"> Shall inform about the requirement of ETS Shall coordinate for locations of ETS at stations as well as cable routing from RTU in TSS/ASS room to ETS locations Shall provide ETS equipment at stations, cross passages and other appropriate locations including TSS and SCR room Shall install PLC cable from nearest ASS, ASS+TSS to ETS equipment
	Viaduct		
9	Installation of 33 kV, 750 V cables, return cables, control cables and other cables on the viaduct	<ul style="list-style-type: none"> Shall give marking for the space on the Viaduct and station area for cable laying Shall coordinate and allow PST Contractor to install suitable cable support infrastructure (metallic brackets, clamps, cable trays etc.) on/in/under the viaduct, in the trench as per requirement for laying of cables. Shall provide suitable opening in viaduct at appropriate location for raising/laying of cable as per the requirements of PST Contractor 	<ul style="list-style-type: none"> Shall coordinate for area of cable laying in view of the walkway and track etc. Shall supply & install 33 kV, 750 V cables and return cables and any other cables on/in/under the viaduct including cable support infrastructure (trays, brackets, clamps etc.) Shall take into consideration the bending radius of cable and covering of cable in public places
10	Earthing, bonding and stray current mitigation arrangements on the viaducts	<ul style="list-style-type: none"> Shall incorporate earthing, bonding and stray current management requirements Shall provide structure earth terminals of viaduct segments for connecting them to Earth Cable Shall coordinate with PST Contractor for verification of earthing bonding and stray current measures adopted in the structure, as per the recommendations in approved design. The Viaduct Contractor shall provide the necessary earth terminals (including holes) for fixing cable lugs on handrail at expansion joint location (Including any discontinuity in handrail) for connection of cable & subsequent connection to Structure earth cables (SEC) as per drawings Provide embedded strips on piers for pier bonding as per drawing To implement the stray current arrangement as per PST GFC drawings 	<ul style="list-style-type: none"> Shall provide schematic arrangement of earthing, bonding and stray current protection management on the viaducts & ensure and certify that earthing, bonding and stray current management scheme is Implemented. This will include cast-in-situ/bridge Shall provide schematic of structure earth terminals, stray current collection mesh in track slab Shall supply and install Structure Earth conductor (SEC) and support/brackets on the viaduct including clamp (both UP and DN direction, including the station area) Shall install and connect structure earth terminals of viaduct segment to Structure Earth Conductor through cable as per specification Shall connect various structures (like handrail, walkway etc.) on viaducts to Structure Earth Cable as per schematic

Item No.	Item Description	Elevated Civil (Viaduct/Station) Contractor	Power Supply & Traction (PST) Contractor
			<ul style="list-style-type: none"> Shall coordinate with Viaduct Contractors for verification of earthing bonding and stray current measures adopted in the structure, as per the recommendations in approved design. Shall provide typical drawings showing arrangement of earth terminal required to be provided for earthing and bonding of the hand rail Shall Connect Hand Rails with SEC Shall connect the pier head strip to SEC with suitable cable and lug arrangement as per drawing
11	Viaducts lightning protection	Shall facilitate the PST Contractor for providing the viaduct lightning protection scheme	<ul style="list-style-type: none"> Shall design and provide lightning protection as per viaducts lightning protection scheme. Lightning protection on viaduct consists of the work of interconnecting the Handrail, connection of handrail to SEC, connecting viaduct segment of piers
	T&C Stage		
12	Earthing and bonding arrangements at viaducts	Shall associate with PST Contractors for verification of earthing and bonding measures adopted in the structure, as per the recommendations in approved design. Shall jointly sign the records.	Shall undertake verification of earthing and bonding measures adopted in the structure, as per the recommendations in approved design. Shall lead the process and sign the records.
	Maintenance Stage		
13	Nil		

2.1.9 INTERFACE WITH PSD/PSG CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	Elevated Civil (Viaduct & Stations) Contractor	PSG/PSD Contractor
	Design Stage		
1	PSD/PSG layout at platform edge	<ul style="list-style-type: none"> Shall incorporate the requirements of PSG system in platform design space, hanger, walls/beams & necessary supports, structural and in platform slab by considering the dimensions, weight and mounting details of PSG, EEG, TAG etc. 	<ul style="list-style-type: none"> Shall furnish design & specifications of PSD/PSG like dimensions, weight, supporting & mounting details throughout the platform Shall furnish requirement of Passenger Emergency Escape Gates (EEG) & Track Access Gates (TAG)

SN	Subject	Elevated Civil (Viaduct & Stations) Contractor	PSG/PSD Contractor
2	Layout of PSD / PSG rooms at the station	<ul style="list-style-type: none"> Shall collect details from PSG Contractor and design the platform to accommodate PSG load requirement Furnish location, room layout with dimensions of PSG Equipment Room in relation to the entire station and facilities layout; Furnish details of architectural finishes of the rooms; 	<ul style="list-style-type: none"> Shall furnish the maximum load of PSG Confirm floor load bearing capacity and room finishes; Furnish weight, dimensions and mounting details of PSG equipment, control panels, UPS unit and other PSG equipment. Furnish layout of PSG equipment Room. Confirm fire safety provisions. Review design with the design Contractor. Co-ordinate closely with construction Contractor to ensure the requirements at site are met.
3	EMC/EMI	Shall incorporate EMI/EMC requirements in station design.	Shall furnish the EMI / EMC levels of PSG equipment to be installed in stations
4	Emergency escape doors	Shall validate and find the locations of passenger emergency escape doors and track access doors	Shall furnish the requirements of passenger emergency escape doors and track access doors
5	PSD/PSG installation location	Shall validate and find the locations of Platform Screen Gate local control panel	Shall furnish the installation location of Platform Screen Gates Local Control Panel on platform level
6	Cable routing	Shall design cable duct/containment for PSD cable routing	Shall furnish the cable routing plan to Station Contractor
C&I Stage			
7	PSD/PSG Installation	<ul style="list-style-type: none"> Shall construct the platform including any groove in the platform edge for installation of the PSG / PSD system including EEG/TAG etc. Coordinate and cooperate for joint survey / inspection with PSG / PSD Contractor 	<ul style="list-style-type: none"> The Contractor shall coordinate with the Civil Works Contractors of each station to confirm the physical arrangements and any modifications thereto. Provide all the required civil works details/inputs including foundations, inserts, openings and other structural works required for the erection of equipment, system and sub-systems, in time for casting, to the Station Civil Contractor. It is the Contractor's responsibility to coordinate with Civil Works Contractor of each station to have joint inspection / survey on Site to ensure that all parts of the Works are provided to the acceptable construction tolerances.
8	Layout of PSD / PSG rooms at the station	Rooms Complete with structures, false ceiling, finishes etc.	<ul style="list-style-type: none"> Construct all false flooring Provide equipment foundations/ pedestals. Install all PSG / PSD equipment
9	PSL Location	Shall provide any cut-out, if required, for PSL	<ul style="list-style-type: none"> Shall coordinate for PSL location at platform end walls

SN	Subject	Elevated Civil (Viaduct & Stations) Contractor	PSG/PSD Contractor
10	Installation of PSDs	Shall provide necessary supports to install the platform screen doors and local control panels	<ul style="list-style-type: none"> Shall install the Platform Screen Gates, Emergency Escape Gates, Track Access Gates etc. and Platform screen doors local control panels
T&C Stage			
11	Insulation of PSD/PSG frames from structure earth	Shall lead the insulation test	Shall associate and verify adequacy of insulation from PSG/PSD perspective
12	System testing	<ul style="list-style-type: none"> Shall attend the joint testing of earth impedance with PSD Contractor Shall attend the joint testing with S&T (PSD) and PST Contractors 	<ul style="list-style-type: none"> Shall conduct a joint test with Station Contractor for testing of earth impedance of all earths provided for the PSD Equipment Shall conduct the joint testing and confirm that there are no EMI / EMC impacts on PSD equipment installed in stations
Maintenance Stage			
13	Nil		

2.1.10 INTERFACE WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	Elevated Civil (Viaduct/Station) Contractor	AFC Contractor
Design Stage			
1	Provision of rooms and areas for equipment layout	Shall incorporate the space and room requirements in the station design	Shall finalize the room schedule and layout for AFC at stations
2	Mechanical and structural interfaces	Shall incorporate the requirements in the station design for: <ul style="list-style-type: none"> Granite counters for Ticket Office (TO) Gate array cable trench and raceway / raise way Passenger windows at TO and EFO (Executive Front Office) Wall opening for TVM at SS Raceway for TVM Tactile path 	Shall provide details of AFC equipment with specific requirements for installation <ul style="list-style-type: none"> Granite counters for Ticket Office (TO) Cable routing and fixing arrangements for cable trays Gate array cable trench and raceway / raise way Passenger windows at TO and EFO Raceway for TVM Fixing arrangement for RCVT Cash box fixing arrangement in counter Tactile path

SN	Subject	Elevated Civil (Viaduct/Station) Contractor	AFC Contractor
3	Furniture / counter in TOM and EFO	Shall incorporate granite counter for TOM and EFO in the design	Shall provide the details of Granite Counter for TOM and EFO
4	Design and Review of documents & drawings	<ul style="list-style-type: none"> Shall incorporate the review comments in the drawings and documents and finalize the station documentation Shall design the Room layout, Station layout, Gate array Counter Glass, Counter hole, tactile path 	<p>Shall review in detail all the drawings and documents for AFC requirements e.g.</p> <ul style="list-style-type: none"> Room schedule Station layout Cable routing Gate array etc. Counter glass Counter hole Tactile path <p>(Not limited to the above drawings and documents)</p>
C&I Stage			
5	Provision of rooms and areas for equipment layout	<ul style="list-style-type: none"> Shall construct the rooms (TOMs& EFOs) and gate area as per the AFC room schedule Shall provide access to AFC Contractor for the installation of equipment 	<ul style="list-style-type: none"> Shall confirm that the construction is as per the room schedule Shall request access from the station Contractor
6	Mechanical and structural interfaces	<ul style="list-style-type: none"> Shall construct and provide civil and structural facilities required for AFC installation Shall coordinate with AFC contractor for the fixing arrangement of RCVT Shall coordinate with AFC contractor for the fixing arrangement of cash box 	<ul style="list-style-type: none"> Shall check and confirm that AFC specific requirements for installation are made available Shall install the electric cabinet and do the cable termination Shall install the switches and do the data cable termination' Shall do the internal wiring at the AFC rooms (TOMs and EFOs) Shall install the AFC equipment at AFC rooms (TOMs and EFOs) and Gate arrays to complete the installation
7	Furniture / counter in TOM & EFO	Shall provide granite counter for TOM and EFO as per approved design	Shall check and verify the details of granite counter for TOMs and EFOs as room schedule given by the AFC Contractor.
8	Review of documents & drawings	Shall provide the GFC/CSD/SEM and as-built drawings and documents as per the documentation plan	Shall review and verify GFC/CSD/SEM and as-built drawings and documents as per the documentation plan
9	Storage at site	To provide temporary storage space for the AFC equipment at concourse level	To check the adequacy of the temporary storage space for AFC equipment at the concourse level and avail
T&C Stage			
10	Nil		
Maintenance stage			

SN	Subject	Elevated Civil (Viaduct/Station) Contractor	AFC Contractor
11	Nil		

2.1.11 INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	Elevated Civil (Viaduct/Station) Contractor	Elevator (Lift) Contractor
Design Stage			
1	Elevator	Design: <ul style="list-style-type: none"> Establish elevator locations and requirement Consider and plan water drainage and protection from rain Consider and plan maintenance access requirements Incorporate elevator monitoring panel location 	Design: <ul style="list-style-type: none"> Provide Civil Contractor with detailed requirements of shaft size, size of ventilation opening, lifting beams / hooks, waterproofing and protection from rain, structural provision etc. Inform the size of access necessary / likely along the passage for moving the elevator for installation Furnish design for monitoring and control panel
C&I Stage			
2	Elevator	<ul style="list-style-type: none"> Provide RCC shaft structure with proper drainage and access Provide lifting hooks / beams at top of shafts and water proofing in pits Provide the load test report of the hooks and the bracket to hold the Guide rail as per the load requirement of elevator Contractor Ramp for access to ground floor elevators Sun shade, rain water protection and water ingress for elevators to be installed in open area Certificate of shaft strength Cladding work around the facia of elevator in all landings beyond the 300mm widths 	<ul style="list-style-type: none"> The Contractor shall satisfy himself with the load bearing capacity of civil structure at location of guide way support and of the lifting hooks beams before starting installation Provide elevator car and all mounting / guide way support and mechanism Provide all exterior finishes and door components for landing doors Supply equipment control and monitoring panel with all accessories Minor civil works like cutting or iron bar / granite stone / concrete for mounting lift fixtures Provide exterior finishes as per Specifications
3	Responsibilities of Contractors for Elevator installation process	DDC / Designer Responsibilities Before Erection <ul style="list-style-type: none"> To identify the entrance elevator shaft with lockable arrangement To issue structural drawings of elevators Cable routing of LED based RMS cable tray in drawings Detailed drawing of phone / alarm / RMS panel in customer care / SCR 	Before Erection <ul style="list-style-type: none"> Provide proper size wooden block for cutout to civil Contractor. To furnish the design for LED Based RMS system. During Erection <ul style="list-style-type: none"> Interface with Civil Contractor and Architect for location of suitable water drainage arrangements.

SN	Subject	Elevated Civil (Viaduct/Station) Contractor	Elevator (Lift) Contractor
		<ul style="list-style-type: none"> To identify and mark on the drawing the Stainless-Steel handrail along with ramp on both side of elevator as per requirement of Elevator Contractor for ground level of ground to concourse Elevator. Identification of location for installation of LED based RMS in SCR <p>During Erection Signage at all landings</p> <p>Construction Contractor responsibilities</p> <p>Before Erection</p> <ul style="list-style-type: none"> Define installation provisions for elevator assemblies, coordinate access and delivery space provisions Adequate storage area at station / depot / storage yard including proper access to storage area from nearby road for carrying elevators by hydra / trailers Future elevator shafts to be protected suitably Cutouts for fixing indicators and for laying of cables at all landings Proper connectivity of drainage hole to nearest sump by suitable GI pipes, drainage pit of elevator should be away from the elevator pit for ease of cleaning. Water proofing in Pit floor. Provision of ventilation^[1] cutout in shaft. Pit Cleaning, PCC work and construction of slope in pit towards drainage hole. Primary whitewash /Paint in shaft. Hole in Slab / Wall for cable entry from E&M shaft to Elevator. Finishing of roof ceiling - painting on load hook etc. above Elevator. <p>During Erection</p> <ul style="list-style-type: none"> PCC filling at entrance sill & sill stone at all landings. Sealing of Rain shelter for entrance elevator / Ground elevator. ^[1]_{SEP} <p>After Erection</p>	<ul style="list-style-type: none"> Provide and install elevator complete with claddings, finishes and operating mechanism. Plan elevator section / sizes considering local site conditions to facilitate easy transportation to installation location. The gap between ELCB Panel & MAP Panel and the Architrave sheet to be filled up by the Elevator Contractor with flexible sealant. Lift number, Job Number & Station Name (in Kannada & English language), Lift capacity plate (in Kannada & English language), Emergency / Safety instruction (in Kannada & English language) License display. Architrave / Granite Stone work coordination. Roof leakage checking/coping stone/slope of roof for Entrance / Ground elevator. <p>After erection</p> <ul style="list-style-type: none"> Filling of gap on elevator shaft on all side & sealing of holes with fire rated material^[1]_{SEP}

SN	Subject	Elevated Civil (Viaduct/Station) Contractor	Elevator (Lift) Contractor
		<ul style="list-style-type: none"> Covering of Gap (b/n stone and Architrave) by stone cladding in all landings. Storage area for maintenance purpose. SS Handrail along with Ramp on both side of elevator as per requirement of elevator Contractor for Ground level of Ground to Concourse elevator. Finishing of patchwork with final whitewash / Paint in lift shaft. 	
4	Temporary power for installation, testing and commissioning.	<ul style="list-style-type: none"> Shall co-ordinate with Civil Contractor for provision of suitable sockets for temporary power. Shall provide required cables and distribution boards. Shall pay to Civil Finishing Contractor for the power consumption. 	<ul style="list-style-type: none"> Shall provide temporary power as per requirement Shall provide suitable meters for calculating the consumption
T&C Stage			
5		Drainage Hole Connectivity to Sump Checking. Load testing of structure, Load hooks & beams.	Shall associate
Maintenance Stage			
6	Nil		

2.1.12 INTERFACE WITH ESCALATOR CONTRACTOR

The Station Contractor(s) and Escalator Contractor shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	Elevated Civil (Viaduct/Station) Contractor	Escalator Contractor
Design Stage			
1	Escalator design related	<ul style="list-style-type: none"> Identify escalator locations and sizes of escalators. Define mounting and structural provisions for escalator assemblies, Co-ordinate access and delivery space provisions. 	<ul style="list-style-type: none"> Co-ordinate details of mounting provisions Furnish the details of intermediate support Furnish the Load hook requirements Furnish the details of hold ups of block work required for shifting the Escalators inside the station. Define requirements and provide design details to Civil Contractor for escalator's various requirements. Furnish sizes for escalator controller enclosures, pit, support details and well way dimensions.

SN	Subject	Elevated Civil (Viaduct/Station) Contractor	Escalator Contractor
			<ul style="list-style-type: none"> Interface with Civil Contractor and Architect for location of suitable hoisting hooks and stray water drainage arrangements.
	C&I Stage		
2	Escalator construction / installation related	<ul style="list-style-type: none"> Provide escalator structure including upper and bottom pits with the notches. The pits shall have gravitational drainage system should connect with the main drainage. Cut outs for fixing traffic bollards and for laying of cables. Providing and fixing of hoisting hooks. Drainage Pit from the escalator should be away from the escalator pit for ease of cleaning. The depth of the sump / drain pit should be more than the depth of Escalator pit for effective drainage. Wall should not be provided beside the escalator pit, to avoid obstruction in opening of covers of escalator pit for maintenance purpose. 	<ul style="list-style-type: none"> Provide and install escalator units complete with claddings, finishes and operating mechanisms. Plan escalator section / sizes considering local site conditions to facilitate easy transportation to installation location. The gap between escalators and the sides of escalator and the adjoining walls/ parapet walls /Stairs shall be provided with decking extensions up to 300 mm. The Contractor shall allow a gap of approximately 15mm between the decking and the adjacent walls/ parapet walls. The gap shall be filled up by the Escalator Contractor with flexible sealant.
3	Responsibilities of Contractors for Escalator installation process	<p>DDC / Designer Responsibilities</p> <ul style="list-style-type: none"> To issue structural drawings for present and future escalator at stations as per vertical rise of escalators and details of the same. Identification of proper (naturally ventilated and protected from rain shower) escalator control panel location for each escalator in consultation with Escalator Contractor. Identification of ECP Room (if ECP panel is not placed in open) in consultation with escalator Contractor. Identification of location for installation of LED based RMS in CCC / SCR <p>Civil Contractor Responsibilities Before erection</p> <ul style="list-style-type: none"> Adequate storage area at station / depot / storage yard including proper access to storage area from nearby road for carrying escalators by cranes / trailers. 	<p>After erection</p> <ul style="list-style-type: none"> RMS cable laying Installation of LED based RMS Panel in SCR and other designated room. Installation of escalator safety instructions in chrome plated stainless steel pipe frame both in Hindi and English language at both landings. Filling of Gap (b/n stone and floor plate). Filling of gap around escalator pit on all side. <p>Testing</p> <ul style="list-style-type: none"> Load testing. Escalator safety testing

SN	Subject	Elevated Civil (Viaduct/Station) Contractor	Escalator Contractor
		<ul style="list-style-type: none"> To protect and cover future escalator shafts suitably. Marking for finished floor level at top support, intermediate supports and bottom support of escalator. Slope of finished floor in the vicinity top and bottom pits of escalator should be away from escalator to prevent entry of mopping water to top and bottom pit of escalators. Adequate extension of roof sheet above the entrance escalator on both sides of escalator for protection of escalator from rain showers. Installation of SS railing with locking arrangement near escalators to prevent theft and sabotage. Pit cleaning, PCC work and construction of slope in pit towards drainage hole. Hole/ Core cutting in Slab / Wall for cable entry from escalator control panel (ECP) to escalator pit, from Escalator Switching Room (ESR) to ECP. Finishing of roof ceiling, painting etc. above escalator. <p>After erection</p> <ul style="list-style-type: none"> Stone of flame finish for making it rough surface. Storage area for maintenance purpose. SS Handrail near top floor plate and bottom floor on both side of escalator as per requirement of Escalator Contractor. 	
	T&C Stage		
4		Drainage hole connectivity to sump checking.	Shall associate
	Maintenance Stage		
5	Nil		

2.1.13 INTERFACE WITH TRACKWORK (TRW) CONTRACTOR

Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	Elevated Civil (Viaduct & Station) Contractor	Track work (TRW) Contractor
	Design Stage		

SN	Subject	Elevated Civil (Viaduct & Station) Contractor	Track work (TRW) Contractor
1	Alignment details	<ul style="list-style-type: none"> Shall share as-built details of station and viaduct structures Sharing of Bench Mark & Co-ordinates with values Station/Viaduct Contractor to share these details and jointly take up traverse survey with the Track Work Contractor and ensure correctness to the required specifications 	<ul style="list-style-type: none"> Shall independently take the as-built details at closer intervals & jointly confirm and finalize / refine the alignment to suit the as-built structures, duly respecting the structure gauge requirements Shall jointly take up transverse survey with station / viaduct Contractor to ensure correctness to the required specifications
	C&I Stage		
	Station Areas		
2	Clearance of track construction envelope	<ul style="list-style-type: none"> Clear and hand over the track construction envelope as per the track construction program Jointly survey the as built levels & Co-ordinates with respect to approved GAD and attend to deficiencies noticed during Joint Inspection. Maintain control points till all works are completed. 	<ul style="list-style-type: none"> Ensure availability of track construction envelope As-built levels and Co-ordinates etc. to be jointly verified with Civil Contractor
3	Storage facilities and utilization of access period for transportation of material to site.	Provide storage space and advise access period for transport of the track material at site.	Transportation of track material to site in specified space and period so that the construction activities systems / infrastructure is not hampered after access period.
4	Temporary water supplies for construction of track.	Shall coordinate	Shall make his own arrangements without affecting the other Contractors' works
5	Details of Cant and horizontal and vertical clearances (Platform levels) of platform coping with respect to track center line	Shall ensure that the Platform coping edge has the required horizontal and vertical clearances with respect to track centerline and rail level respectively.	Shall take into account these values for track installation
6	Construction of track slab	Provisions of vertical stirrups / shear connectors / dowels on tunnel/station base as per the GFC drawings.	Construction of slab utilizing the provisions of vertical stirrups/ shear connector / dowels
7	Details of track drainage.	<ul style="list-style-type: none"> Design and construction of drainage system except the drains required within track. Furnish details of levels of drainage systems. 	Design and construction of drains required within track based on details of levels of drainage system provided by Station Contractor
	Mid-section (viaduct)		
8	Handing over of track formation	Jointly survey the As-built levels/Co-ordinates w.r.t approved GAD and attend to deficiencies	As-built levels and Co-ordinates etc. to be jointly verified with Civil Contractor

SN	Subject	Elevated Civil (Viaduct & Station) Contractor	Track work (TRW) Contractor
9	Construction of track slab	Shall ensure that the design and construction of deck and substructure caters to the LWR forces and derailment loads and furnish the bed conforming to the correct alignment and levels of deck as per drawings, to Track work Contractor	Shall give details of the plinths/slabs of the track including rail level from top of the deck and also location of shear connectors / dowels between the slab and deck concrete
10	Shear connectors in viaduct deck, Tunnel/Station base.	Provisions of vertical stirrups / shear connectors / dowels on viaduct deck as per the GFC drawings for casting of segment/ viaduct deck slab.	Construction of plinth / slab utilizing the provisions of vertical stirrups / shear connector / dowels and ensure that the derailment up stand is constructed
11	Turnout / crossover locations	Shall ensure that design of deck and substructure and location of expansion joints of the deck caters to the Turnouts / Crossovers locations.	Shall provide locations and details of the Turnouts / Crossovers with respect to the center, criteria for deck such as location of expansion joints
12	Details of track drainage	<ul style="list-style-type: none"> Design and construction of drainage system of Viaduct except the drains required within track. Furnish details of levels of drainage systems 	Design and construction of drains required within track based on details of levels of drainage system
13	Clearance of track construction envelope	Clear and hand over the track construction envelope as per the track construction program	Ensure availability of track construction envelope
14	Storage facilities and utilization of access period for transportation of material to site.	Provide storage space and advise access period for transport of the track material at site and on to the viaduct.	Transportation of track material to site and viaduct in specified space and period so that the construction activities systems / infrastructure are not hampered after access period.
15	Temporary water supplies for construction of track	Shall coordinate	Shall make his own arrangement without affecting the other Contractors' works.
	T&C Stage		
16	Checking of track construction envelope	Shall cooperate and associate and jointly sign the test / checking record Shall undertake remedial measures, if any relevant to his work (e.g. platform / parapet edge chipping etc.)	Shall cooperate, associate and jointly sign the test / checking record
	Maintenance Stage		
17	Nil		

2.1.14 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

General

- 2.1.14.1 BMRCL has plans to implement state-of-the-art IT-based Enterprise Asset Management System (AMS), which shall enable BMRCL to manage and optimize various processes (viz. maintenance management, engineering management, O&M relationship management, supply chain management, reporting etc.)
- 2.1.14.2 The Contractor shall be required to coordinate and interface with AMS Contractor for successful integration of assets / permanent works into the Asset Management System.
- 2.1.14.3 The assets / components / equipment to the required levels of breakdown shall be entered into the AMS.
- 2.1.14.4 The asset data shall be fed into the AMS broadly in three forms:
- (a) Predetermined set of active failures shall be transmitted in real time to OCC via relevant network. AMS shall be able take in this data for processing.
 - (b) Data shall be downloaded through GPRS or WLAN at predetermined intervals or locations. AMS shall be capable of interfacing with the concerned database and take in filtered data as per design.
 - (c) Other data will be fed manually in the AMS.
- 2.1.14.5 Preventive and corrective maintenance data generated by the relevant system to raise the work request /work orders, and to update the equipment parameter reading
- 2.1.14.6 The point of interface to the AMS will be the AMS depot (or other location) rack via Ethernet LAN connectivity.

Responsibilities of Interfacing Parties

- 2.1.14.7 Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	Elevated Civil (Viaduct/Station) Contractor	IT/AMS Contractor
1	Data input format	Shall furnish specific requirements of format creation	Shall design the data input format in consultation and duly taking into account the suggestions of Interfacing Contractor
2	Asset data entry to AMS system	Shall be responsible for inputting data related to its assets in the AMS system	Shall guide, support and coordinate
3	Creating an Interface Design for Data exchange	Shall lead	Shall guide, support and coordinate
4	Interface design document signoff	Shall coordinate	Shall lead
5	Developing interface to push data to AMS	Shall coordinate	Shall lead
6	Receiving and processing data to create work requests in AMS	Shall coordinate	Shall lead

SN	Subject	Elevated Civil (Viaduct/Station) Contractor	IT/AMS Contractor
7	Preparing test data for test cases	Shall coordinate	Shall lead
8	Preparing test Cases for interface Test	Shall coordinate	Shall lead
9	Testing Interface for required functionality	Shall coordinate	Shall lead
10	Test Report Sign Off	Shall coordinate	Shall lead
11	Deploying the interface on Test/ Production Environments	Shall coordinate	Shall lead
12	Technical Design Document submission and Sign Off	Shall coordinate	Shall lead
13	Cyber Security	The Contractor shall be required to engage with designated Cyber Security Consultant at the early stage of design development. The Contractor shall consider the inputs of Cyber Security Consultant into their design and develop their System Safety & Cyber Security Assurance Plan and submit to BMRCL for approval.	The IT/AMS Contractor shall recommend Cyber Security Guidelines complying the requirements of related standards

CHAPTER 3

3.0 UNDERGROUND CIVIL CONTRACTORS' INTERFACES

3.1.1 INTERFACE WITH DESIGNER / DESIGN WING / CONSULTANTS

The Contractor is responsible for coordinating and interfacing with following:

- (i) Detailed Design Consultants if engaged by BMRCL for various reaches / sections
- (ii) In-house Design Wing of BMRCL
- (iii) Agency which BMRCL has engaged for preparation of project DPR
- (iv) Survey agency engaged by BMRCL
- (v) Geo-tech investigating agency engaged by BMRCL
- (vi) Any other design agency / consulting agency engaged by BMRCL which has relevance for Contractor's work

3.1.2 INTERFACE WITH UTILITY AGENCY

The Contractor is responsible for coordinating and interfacing with following agencies:

- (i) BBMP
- (ii) BWSSB
- (iii) BESCOM
- (iv) Other utilities / civic agencies
- (v) Karnataka State Fire & Emergency Services
- (vi) Any other Statutory Authorities

3.1.3 INTERFACE WITH UNDERGROUND E&M CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	UG Civil Contractor	UG E&M Contractor
	Design Stage		
1	Equipment rooms, sumps, conduit and ducts	<ul style="list-style-type: none"> Provide CSD based on inputs from E&M Contractor Incorporate input from the E&M Contractor in the production of Structural E&M Drawing (SEM) that will show all the necessary opening, plinths Prepare equipment route drawings. 	<p>Provide input data for E&M system equipment, sizing & requirements Sump collection tank etc.</p> <p>Provide major equipment weight and sizing for E&M system to enable suitable SEM and sizing at the station.</p>
	C&I Stage		

Item No.	Subject	UG Civil Contractor	UG E&M Contractor
2	Equipment rooms, sumps, conduit and ducts	<ul style="list-style-type: none"> Provide structural openings construction of pedestals, niches, plinths, cable trenches, Embedded conduits, sleeves for use of the E&M Contractor Complete equipment rooms, sumps and other spaces for the installation of the E&M equipment such as pumps and control panel 	<ul style="list-style-type: none"> Install E&M equipment as required in the E&M scope of works at locations and routing provided by the Station Contractor Provide raceways, trenches for the E&M works, and other system Contractor for all routes defined in the CSD's Closing of all floor and wall openings (including unused floor and wall openings specifically provided for E&M) provided by Civil Contractor with fire rated material after installation of all E&M services including openings used by designated Contractors.
3	Temporary power for installation, testing and commissioning.	<ul style="list-style-type: none"> Civil to provide temporary power and water supply as per E&M's requirement Shall provide suitable meters for measurement of actual power and water consumed the E&M Contractor 	<ul style="list-style-type: none"> Shall co-ordinate with Civil Contractors for provision of Temporary power supply & water supply for the purpose of E&M work. Shall pay to Civil Contractor for the actual water and power consumption.
	T&C Stage		
4	Nil		
	O&M Stage		
5	Nil		

3.1.4 INTERFACE WITH UG STATIONS FINISHING CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	UG Civil Contractor	UG Station Finishing Contractor
	Design Stage		
1	Station design including all passenger areas and equipment rooms	Design and coordination with Finishing Contractor	Furnish the requirements related to Finishing Works for incorporation in the designs
	C&I Stage		

Item No.	Subject	UG Civil Contractor	UG Station Finishing Contractor
2	Station construction including all passenger areas and equipment rooms	Civil and structural construction of the station as per agreed designs duly in coordination with Finishing works Contractors as well as other designated Contractors	Finishing works of the station as per scope of work in coordination with Civil Contractor as well as other designated Contractors
	T&C Stage		
3	Nil		
	O&M Stage		
4	Nil		

The following interfaces apply between UG Civil Contractor and Signage Contractor (in case signage is separate scope and not part of Finishing Contractor):

Item No.	Subject	UG Civil Contractor	Signage Contractor
	Design Stage		
1	Signage	<ul style="list-style-type: none"> Design details to be worked out in coordination with signage design requirements Shall accommodate the civil requirements for the signage works as per the CSD 	<ul style="list-style-type: none"> Shall design signages and graphic design Shall provide the details of signages with dimensions, weight etc., as CSD inputs Shall review the CSDs
	C&I Stage		
2	Temporary power for installation, testing and commissioning	<ul style="list-style-type: none"> Shall provide temporary power as per requirement Shall provide suitable meters for calculating the energy consumption 	<ul style="list-style-type: none"> Shall coordinate with Civil Contractor for provision of suitable sockets for temporary power Shall provide required cables and distribution boards Shall pay to Civil Contractor for the power consumption
	T&C Stage		
3	Nil		
	O&M Stage		
4	Nil		

3.1.5 INTERFACE WITH SIGNALING & TRAIN CONTROL (S&TC) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	UG Civil Contractor	S&TC Contractor
	Design Stage		
1	Layout of rooms at the station – Train Control equipment, and Station control rooms.	<ul style="list-style-type: none"> Develop location, room layout with dimensions of Train Control equipment room, and station control room in relation to the entire station and facilities layout; Develop routing of Cable ducts / within and between Train Control equipment, UPS and station control rooms. Furnish details of architectural finishes and building materials of the entire station; Design details to be worked out in interface with S&TC System design requirements; Provision of space for Emergency Stop Plunger (ESP) 	<ul style="list-style-type: none"> Confirm basic room sizes; Furnish equipment dimensions, weights and colours. Furnish equipment foundation/ mounting / base frame details; Confirm room finishes; Furnish cabling requirements including destinations, sizes, quantities and cable loadings of Cable ducts / conduits / hangers / trays within and between Train Control, equipment, and station control rooms. Furnish requirements of cable bores on walls / floor penetrations, complete with pipe, sleeves for routing of all types of cables Furnish requirements of EMC/EMI and fire separation for cabling Furnish air-conditioning / ventilation, lighting and power socket requirements; Confirm fire safety provisions; Review the design from Designated Tunnel Construction Contractor(s). Review design with the DDCs. Co-ordinate closely with Station Construction Contractors to ensure the requirements at site are met.
2	Cabling infrastructure for S&TC Equipment	<ul style="list-style-type: none"> Furnish sectional details of tunnel including structure gauge, architectural finishes and building materials; Furnish details of architectural finishes and building materials of the entire station; Develop routing of Cable ducts / conduits / hangers / trays for Train Control cables throughout the station and each tunnel section. Design details to be worked out in interface with S&TC System design requirements. 	<p>Trackside:</p> <ul style="list-style-type: none"> Furnish dimensions, weight minimum bending radius supporting and mounting details of Fiber Optic Cable, Cu- cable, Outdoor / indoor Sig. Furnish and confirm size, cable loadings and location of Cable ducts / conduits / hangers / trays for Train Control (Fiber Optic Cable, Cu-cable, Outdoor / indoor Sig. cables along each track in the tunnel / section. Furnish dimensions, weight supporting and mounting details of emergency telephone units at each cross passage along the tunnel section. Furnish size of cross track cable ducts, Furnish requirements of EMC/EMI and fire-separation for cabling. Review the design from Designated Tunnel Construction Contractor(s).

Item No.	Subject	UG Civil Contractor	S&TC Contractor
			At Stations: <ul style="list-style-type: none"> Furnish dimensions, weight minimum bending radius supporting and mounting details of Optic Fiber Cables, Cu – cables, CBTC radio antenna feeder cables and cables for Train Control, and UPS power supply / earth distribution, furnish destination of each cable, Furnish & confirm size, cable loadings and location of Cable ducts / conduits / hangers / trays for routing Train Control cables throughout the station. The cabling shall include, but not be limited to Optic Fiber Cables, Cu-, CBTC radio antenna feeder cables and cables for Train Control, UPS power supply / earth distribution, confirm size of cross track cable ducts; Furnish requirements of EMC/EMI and fire separation for cabling Review the design from Designated Tunnel Construction Contractor(s).
3	Trackside S&TC Equipment	<ul style="list-style-type: none"> Provision of space and Cast in fixing arrangements for line-side equipment such as CBTC radio antennae, junction boxes, etc. Design details to be worked out in interface with S&TC design requirements. 	<ul style="list-style-type: none"> Furnish the exact sizes, weight and fixing arrangements of the line side equipment such as, junction boxes, signals, signaling ladder, CBTC communication equipment, etc. Review the design from Designated Tunnel Construction Contractor(s).
4	Train Radio Access Points	Design details to be worked out in interface with S&TC design requirements in station areas and tunnels	Furnish the locations, dimensions and load for Train Radio Access Points in station areas and tunnels
5	Station Control Room: Space for workstations / ESP and other Signalling equipment.	Design details to be worked out in interface with S&TC design requirements;	<ul style="list-style-type: none"> Furnish weight, dimensions, colours and mounting details of work stations/control panels/ Radio access unit and all Train Control system Equipment. Shall closely coordination with the DDCs and/ or Station construction Contractor.
6	Provision of Earthing at stations in S&TC equipment rooms, Station Control room, UPS/Battery room. Earthing bus along the tunnel/ box wall. (Refer Para 0 below for details)	<ul style="list-style-type: none"> Design details to be worked out in interface with S&TC design requirements; Design of earth and earth bus bar of < 1Ω 	Furnish requirements for clean earth and main earth review the design from Designated Tunnel Construction Contractor(s).

Item No.	Subject	UG Civil Contractor	S&TC Contractor
7	Interconnection between Lines at relevant stations – for cable laying.	<ul style="list-style-type: none"> Develop routing of Cable ducts / conduits / hangers / trays at stations where lines interconnect. Design details to be worked out in interface with S&TC design requirements; 	<ul style="list-style-type: none"> Furnish cabling requirements including destinations, sizes, quantities and cable loadings of Cable ducts / conduits / hangers / trays at stations where lines interconnect. Furnish requirements of cable bores on walls / floor penetrations, complete with pipe, sleeves for routing of all types of cables Furnish requirements of EMC/EMI and fire separation for cabling Review the design from Designated Tunnel Construction Contractor(s).
Const./Install. Stage			
8	Layout of rooms at the station: Signalling Equipment room (SER), UPS, Signalling maintenance room, and Station control rooms (SCR).	Construct the rooms as per the design, providing cut outs, shafts, false flooring, false ceiling, fire rated doors, cable trenches for S&T UPS Room, checkered plate for cable trench cover in UPS room etc. as required.	<ul style="list-style-type: none"> Provide equipment foundations / pedestals / base frames. Install all S&TC equipment, cables, cable trays under false floors etc. Seal the gaps after cable installation work with fire resistant material.
9	Cabling infrastructure for S&TC Equipment	<ul style="list-style-type: none"> Provide for routing all type of cables for Train Control systems throughout the station and tunnel sections. Fiber optic cables throughout the station and tunnel sections shall have route diversity. Cross track Cast in cable ducts. Provision of space for line side equipment viz. signal, antenna pole, point machine, signal boxes, location box, signalling ladder etc. 	<ul style="list-style-type: none"> Coordinate with UG Contractor for necessary provisions Construct all secondary ducts including track crossings (cable hanger to equipment) and partitioning / providing cable trays channels in main cable ducts as required. Install cables for all Signalling systems Install all line side equipment including equipment foundations etc.
10	Trackside S&TC Equipment.	Provide the Cast in fixing arrangements for line-side equipment.	Install all cables for Train Control system. Install all line side equipment such as junction boxes, signals, signaling ladders, Balise and CBTC communication equipment, etc.
11	Train Radio Access Points	Tunnel wall for Antenna mounting Structures for Train Radio Access Points in station areas and tunnels	Install mounting structures, Radio Access Points and feeder cables in station areas and tunnels
12	Station Control Room: Space for workstations / ESP and other Signalling equipment.	Construct the room to be requirement of S&TC Contractor	Installing all Train Control system Equipment

Item No.	Subject	UG Civil Contractor	S&TC Contractor
13	Provision of Earthing at stations in S&TC equipment rooms, Station Control room, UPS/Battery room. Earthing bus along the tunnel/ box wall. (Refer Para below for details)	<ul style="list-style-type: none"> Install earth mats separate for clean earth and main earth at stations and tunnel. Installation of Earth bus bar $< 1\Omega$ and earth 	Set up the earth bus inside Train Control equipment rooms, Station control room and UPS/Battery room.
14	Interconnection between Lines at relevant stations – for cable laying.	<ul style="list-style-type: none"> Cable ducts / conduits / hangers / trays at stations where lines interconnect. Cast in cable ducts on walls / floor penetrations, for routing of all types of cables 	<ul style="list-style-type: none"> Install Train Control cables. Seal all gaps after cable installation work.
	T&C Stage		
15	Provision of Earthing at stations in equipment rooms.	Perform the earth resistance measurement	Associate and verify the measured earth resistance; jointly sign the record
	Maintenance Stage		
16	Nil		

Earthing and lightning protection to be provided by the Designated Tunnel Construction Contractor(s) and Civil Construction Contractor to meet the Interface Requirements of the S&TC Contractor

3.1.5.1 Objectives

Earthing points shall be provided by the Designated Tunnel Construction Contractor(s) and Civil Construction Contractor for all indoor S&TC installations to achieve the following objectives:

- To provide the safety to the operating and maintenance personnel against the electric shock on account of any potential (voltage) appearing on exposed parts with respect to earth or due to electromagnetic or due to electrostatic induction.
- To ensure safe and reliable operation of the equipment by limiting or eliminating the induced voltages and transients in the S&TC equipment.
- To protect the equipment against buildup of unduly high voltages; this may cause dielectric (Insulation) breakdown, or damage to equipment, or their components.
- To serve as common voltage reference point wherever required.

3.1.5.2 General Earthing Policy

- 3.1.5.2.1 The Earthing system shall meet or exceed the requirements of IEEE 1100, NFPA 780 and IEC 62305 or relevant international standards.
- 3.1.5.2.2 Earthing and other protection devices shall be designed by Designated Tunnel Construction Contractor(s), Civil Construction Contractor, S&TC Contractor to accomplish the following minimum requirements, but not be limited to:
- (a) Protection of personnel and equipment from electrical hazards, including lightning.
 - (b) Reduction in potential to system neutrals.
 - (c) Reduction or elimination of the effects of electrostatic interference and electromagnetic interference arising from within the auxiliary electrical systems and other extraneous sources in the vicinity of S&TC installations
 - (d) Provision of a proper earthing method for all equipment enclosures, cabinets, drawers, assemblies and sub-assemblies.
 - (e) Provision of a clean zero-volt reference point where required.
- 3.1.5.2.3 The earthing system shall be so designed by Designated Tunnel Construction Contractor(s) and Civil Construction Contractor so as to give earth resistance within the stipulated limits at all locations and under all climatic conditions.
- 3.1.5.2.4 Any electrical joints in the earthing system shall be protected from moisture ingress by using proper wrapping, sealing with waterproof tape, or such other approved measures.
- 3.1.5.2.5 For the purpose of measurement of earth resistance, a small interconnecting copper strip of appropriate cross-section shall be provided in the ring earth in a small accessible chamber so that the ring earth can be broken from the loop for testing.
- 3.1.5.3 Stations area and OCC (Indoor Equipment)

3.1.5.3.1 Clean Earth System

“Clean Earth system means earth network for the use of particular systems which are not to be subjected to electrical interference from other systems.”

There shall be separate and independent “Clean-Earths”; between train control equipment and other equipment (separate from system earth i.e., main electrical earth bus for other utilities). These earths shall cater for the S&TC Equipment to be provided inside the equipment rooms at the Station/Control center. These earths shall be brought inside the equipment rooms using insulated copper conductors and connected to the “Clean-earth terminals” using isolating link. It shall provide full earth, fault protection facilities. A local “Clean- earth” bus shall be setup inside the equipment rooms by running a copper strip. The route chosen for the insulated clean earth conductor shall minimize inductive interference from power-supply cables and the main earth network.

These “Clean-Earths” shall be designed so as to give not more than 0.5 Ohm resistance in dry condition. The earths shall make use of copper electrodes of appropriate size. The earthing electrodes for these equipment earths shall be kept at least 20m away from the “Main-Earth” provided for electrical systems & utilities.

3.1.5.3.2 Main Earth

Apart from these clean earths, one earth point shall also be provided from the "Main-Earth" bus in each of the S&TC equipment rooms, Station Control room (SCR) and UPS/Battery room at the station OCC. This shall be used as the chassis earth. The value of this earth should not be more than 1.0 Ohm at any location and under any climatic condition.

The Tunnel Contractor and Civil Construction Contractor shall provide the earthing pits for clean earths and main earth and shall connect them up to the earthing terminals inside the rooms as above. S&TC Contractor shall set up earthing ring bus inside the operational rooms. Both the Contractors shall jointly set up machinery to achieve the desired earth resistance values.

3.1.5.4 Out Door Installations

The following outdoor installations are required to be earthed:

- (a) Metallic sheath and armoring of all main cables at regular intervals;
- (b) Junction Boxes;
- (c) Radio Access Point posts;
- (d) Point Machines;
- (e) Signals; and
- (f) Any other installation as may be necessary to cover complete scope of works under S&TC package

An Earth bus shall be provided by the Designated Tunnel Construction Contractor(s) all along the wall of the tunnel. The earth bus shall be so designed so as to give an earth resistance of not more than **One Ohm** under dry condition. The earth bus shall be connected to a minimum of two earth pits, one on each side of the tunnel, if necessary; the additional earth pits may be made by Designated Tunnel Construction Contractor(s) in the Tunnel X-passages. The earthing shall use Cu-electrodes in order to reduce corrosion & the maintenance efforts in the underground section. All the line side S&TC installations shall use this earthing bus.

3.1.5.5 Guidelines for Transient Protection and Lightning Protection

3.1.5.5.1 Despite the provision of earthing as specified above, failures of Solid-State Electronic equipment do occasionally occur on account of finite earth resistance, particularly high voltage transients and also due to lightning.

3.1.5.5.2 Typically, transient & lightning are temporary, and are usually short duration, surge voltages of limited energy. Electronic equipment with high input impedance is inherently more susceptible to transients.

3.1.5.5.3 Lightning Protection

While the Station/Control center above ground structures shall be provided with lightning protection arrangements by Designated Tunnel Construction Contractor(s) and Civil Construction Contractor, the protection against lightning surges travelling through conductors into equipment side shall be done by the S&TC Contractor using appropriate devices in accordance with the S&TC Contract document and prevailing international practices.

3.1.6 INTERFACE WITH ROLLING STOCK CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	UG Civil Contractor	Rolling Stock Contractor
	Design Stage		
1	Car Details	Requires details of Rolling stock including length of train cars, height and location of doors for station design.	Shall furnish required details of Rolling stock including Length of train cars (with front coupler), height and location of doors for station design
2	Kinematic and structural gauges	Shall obtain details of kinematic and structural gauges from Rolling Stock Contractor and take into account during design to ensure platform and walkway. clearance while train is running.	Shall furnish the details of kinematic and structural gauges respective to all speeds
3	UG Design	<ul style="list-style-type: none"> Shall provide the space proof details to Rolling stock Contractor Shall obtained details of kinematic and structural gauges from RS Contractor 	<ul style="list-style-type: none"> Shall coordinate with UG Civil Contractor Shall provide the details of kinematic and structural gauges
4	Design of walkway slab and Emergency Ramp	Walkway slab shall be designed as per SoD and with interaction of system contractor (RS).	<ul style="list-style-type: none"> Shall study the track geometry including horizontal and vertical profile for the entire project. The project is designed with side evacuation. The Rolling Stock Contractor and Track Contractor shall jointly submit the calculation of horizontal and vertical shift of car body on inside curve and outside curve in stationary condition and running condition. Shall design the emergency ramps and provide suitable enclosures for housing the ramps inside the train.
	C&I Stage		
5	Clearances checking with respect to platform alignment	Shall jointly check and confirm the curves, dimensional clearances, gradients, chainages, levels and emergency escape provision	Shall co-ordinate and confirm with station Contractor
6	Construction & Installation	Shall participate in test run and perform modifications, if required	Required to conduct test run with one car at low speed in the viaduct sections
	T&C Stage		
7	Integrated testing	Shall coordinate with RS Contractor to complete testing and commissioning work	Require to conduct integrated test with all systems
8	Gap measurement at walkway and platform	Shall jointly check and measure the gap between walkway/platform and coach floor and shall rectify the defects noticed	Shall provide train
9	Structure gauge checking	Shall jointly measure the various clearances required for structure gauge and shall rectify the defects noticed	Shall provide structure gauge and manpower.

SN	Subject	UG Civil Contractor	Rolling Stock Contractor
10	KE test	<ul style="list-style-type: none"> Shall jointly check whether KE infringement is there or not Shall rectify the defects noticed. 	Shall provide the train with KE profile
	Maintenance Stage		
11	Nil		

3.1.7 INTERFACE WITH TELECOMMUNICATION (TEL) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	UG Civil Contractors	Telecom Contractor
	Design Stage		
1	Layout of relevant equipment rooms at the station	<ul style="list-style-type: none"> Shall prepare and provide station layout and drawings showing the rooms and vertical cable risers etc. Shall Update the Station drawings to accommodate the requirements of Telecom Contractor. Shall incorporate room requirements and routing of Cable ducts / cable trays, pedestal / base frames in the designs Shall provide the cutout above the false ceiling, below the false flooring of the TER, SCR, UPS, CDMA rooms as per inputs by Telecom Contractor. Shall collect the data & integrate with other users and provide it to all the Interfacing / Project Contractors. All corridors and doors shall be sized to enable equipment to be delivered to TER, CER, SCR, CDMA, TOR and Telecom Closets for installation and replacements 	<ul style="list-style-type: none"> Shall furnish the size, space and mechanical load requirements of the Communication Equipment Room (CER), Station Control Room (SCR), Telecom closets and lighting, flooring, false flooring, cable duct and vertical cable risers in the above-mentioned rooms Mark require requirements in close coordination with the civil design / construction Contractor. Review design with the civil design Contractor. Coordinate closely with construction Contractor to ensure the requirements at site are met. Shall furnish all design of pedestals/ base Frames layouts for all systems rack, etc. in TER.
2	Cable routing and other equipment	<ul style="list-style-type: none"> Shall establish the synthesis layout for cable routing according to all the Sub-systems layouts Shall design the cable routing and cable containments in the station For heavy equipment like CCTV monitors, display boards, analogue clocks etc., to be mounted on 	<ul style="list-style-type: none"> Shall furnish the routing of the cables for Telecom equipment in whole Station Shall validate the synthesis cable routing layout proposed by UG Station Contractor Shall furnish the detailed drawings of main cable routing arrangements in respect of Telecom cables

SN	Subject	UG Civil Contractors	Telecom Contractor
		walls / suspended from the roof, UG Station Contractor shall integrate the fixing arrangements with the structural design.	<p>in the station (including requirements of minimum 1-meter separation between Telecom cables and HV cables). Shall furnish the details of Telecommunication cables like dimensions, weight, minimum bending radius and supporting & mounting details.</p> <ul style="list-style-type: none"> Shall provide detailed drawings with the locations of all equipment and cables to be installed on the track. Shall provide detailed drawings of locations, loads, type of fixing / mounting arrangements for Telecommunication equipment to be installed on the platform, Mezzanine (where applicable), concourse and entrance levels like PA system, PID's, CCTV cameras, clocks, CCTV monitors, emergency stop plungers and staff protection keys etc.
3	Station Control Room	<ul style="list-style-type: none"> Incorporate design requirement of Telecom Contractor in the SCR/TER, CDMA & TOR room viz. Space for workstations / and other telecom equipment etc. Shall incorporate room requirements providing cutouts, in the SCR/TER, pipes & chamber of size mm 500*500*400 (W*L*H) in the technical corridor. 	<ul style="list-style-type: none"> Shall furnish layout of telecom equipment within Station Control Room and Telecom equipment room Shall mark the cable trays, cut outs, pipes & chamber on the station drawings in close coordination with the DDC/ UG Civil Contractors. Shall review the design with the DDC/ UG Civil Contractors. Co-ordinate closely with Station Construction Contractor
4	TETRA Radio Tower	Shall incorporate the requirement of radio tower stations' design as per the requirement of Telecom Contractor.	Shall provide design requirements for radio tower and shall coordinate appropriately
5	Provision of Earthing at stations in telecom equipment rooms	Design of earth and earth bus bar < 1Ω	Associate for design as required
6	Track side equipment & Cabling infrastructure for telecom system	<ul style="list-style-type: none"> Incorporate in the tunnel design the provisions for telecom cables throughout the guide ways. Design details to be worked out in interface with Telecom Contractor design requirements. 	<ul style="list-style-type: none"> Design cable hangers/ cable ducts, cross track cast in cable ducts for main telecom cables throughout the guide ways. Fiber optic cables throughout the guide ways shall have route diversity. Furnish and confirm sizes and bending radius of trays, hangers, main cable duct and cross track cable ducts for main cables in close coordination

SN	Subject	UG Civil Contractors	Telecom Contractor
			with the civil design and/ or construction Contractor. <ul style="list-style-type: none"> Furnish locations of line side equipment. Furnish and review requirements of EMC separation for cabling. Review the design from detailed design Contractors.
7	Emergency communication	Shall validate the locations of passenger emergency communication system and help point system	Shall furnish the locations and space requirements of passenger emergency communication and help point equipment to be installed
8	ACID System	Shall validate the locations of access control system and intrusion detection system	Shall furnish the locations and details of access control system and Intrusion detection system
9	EMC/EMI	<ul style="list-style-type: none"> Shall incorporate in station design and prepare a common EMI / EMC plan Shall attend the joint testing with S&T, RS and PST Contractors 	<ul style="list-style-type: none"> Shall furnish the EMI / EMC levels of Telecom equipment to be installed in stations Shall conduct the joint testing and confirm that there are no EMI / EMC impacts on Telecom equipment installed in stations
10	PAS/PIDS system	Shall accommodate the requirements of Telecom Contractor and furnish the architectural design details of the stations	Shall furnish the acoustic intelligibility and lighting visibility criteria to ensure that the performance of PA and PID systems are as per laid down standards
11	Temporary power	Shall plan the power supply system accordingly	Shall furnish the requirements of temporary power supply for preliminary testing of S&T equipment installed in stations
12	PAS interface with Fire System	<ul style="list-style-type: none"> Shall design the interfacing of fire system with PA system etc. and provide the relevant technical specifications of fire protection system Shall install the fire alarm and control system and provide the necessary interfaces with PA system 	<ul style="list-style-type: none"> Shall validate the interface document and relevant portion of technical specifications of fire protection system Shall verify the interfacing of fire system with PA system
C&I Stage			
13	Layout of relevant equipment rooms at the station	Rooms complete with structures, false ceiling if necessary, finishes, fire protection, doors, etc.	<ul style="list-style-type: none"> Provide equipment foundations/ pedestals. Install all telecom equipment, cables etc. Seal the gaps after cable installation work with fire resistant material.
14	Station Control Room	Construct the SCR room as per approved design	Install telecom equipment within Station Control Room.
15	TETRA Radio Tower	<ul style="list-style-type: none"> Shall construct the structure to enable installation of radio tower 	<ul style="list-style-type: none"> Shall install the radio towers
16	Provision of Earthing at stations in telecom equipment rooms	<ul style="list-style-type: none"> Install earth mats separate for clean earth and main earth at stations and tunnel. Installation of Earth bus bar < 1Ω and earth 	<ul style="list-style-type: none"> Set up the earth bus inside equipment room from the earth bus bar provided in UPS room.

SN	Subject	UG Civil Contractors	Telecom Contractor
17	Construction and Installation	Shall install the mounting and fixing arrangements for heavy equipment like CCTV monitors, display boards, analogue clocks etc., during the construction as per the Telecom Contractor's requirements.	<ul style="list-style-type: none"> The fixtures will be to be designed and installed by Telecom Contractor. Primary Fixtures & Secondary Fixtures for Telecom equipment shall be provided by Telecom Contractor as per aesthetics of the Station architecture. Sample to be get approved from BMRCL.
18	Track side equipment & Cabling infrastructure for telecom system	<ul style="list-style-type: none"> Provide for routing all type of cables for Train Control systems throughout the station and tunnel sections. Provision of space for line side equipment. Provide drainage in viaduct 	<ul style="list-style-type: none"> Construct all secondary ducts including track crossings and partitioning/ providing cable trays/ channels in main cable ducts as required. Install cables for telecom system including provision of all cable supports. Install all line side equipment including equipment foundations
19	Equipment room handover	Shall provide the lighting, vertical cable risers in TER, Telecom Closets and SCR	<ul style="list-style-type: none"> Shall verify that the requirements of lighting, vertical cable risers in TER, Telecom Closets and SCR are as per the requirement Shall provide false flooring in telecom equipment room
20	Cable laying	Shall ensure provision of cable ducts, main cable crossing arrangements, including openings required for entry / exit arrangements for main Telecom cables in the station	Shall install all communication cables and provide the connections to individual devices
21	Line side equipment installation	Shall provide the necessary arrangements to install line side telecom equipment	Shall install the line side Telecom equipment like antennas, location boxes, telephones etc.
22	Emergency communication	Shall provide necessary arrangements to install emergency communication and help point equipment	Shall install the emergency communication and help point equipment
23	ACID System Installation	Shall provide necessary arrangements to install access control and intrusion detection systems	Shall install the access control system and intrusion detection system
T&C Stage			
24	Provision of Earthing at stations in equipment rooms.	Perform the earth resistance measurement of the main and clean earth mats	Associate and verify the measured earth resistance; jointly sign the record
Maintenance Stage			
25	Nil		

3.1.8 INTERFACES WITH POWER SUPPLY & TRACTION (PST) CONTRACTORS

Provision of [Para 0 above](#) applies as relevant for UG sections

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Item Description	UG Civil Contractors	Power Supply & Traction (PST) Contractor
	Design Stage		
1	All interface issues related to station building	<ul style="list-style-type: none"> • Shall interface with PST Contractor and factor in the relevant requirements in ASS/TSS/station civil/structure designs • Shall ensure that no expansion joints are provided on the roof above ASS and ASS/TSS room • Shall accommodate the civil requirements for the traction works as per the CSD 	Shall furnish the requirements of: <ul style="list-style-type: none"> • ASS/TSS rooms layout design • Equipment ingress / egress route requirements • Weight and dimension of cables / equipment • Cable paths (ducts, trays, brackets etc.), gallery size, route alignment, mounting arrangement of cables, bending radii of cables • Earthing, bonding and stray current mitigation related requirements • ETS related requirements • Platform insulation • Earthing / mat design calculations (and verify earth mat installation designs) • Shall furnish the requirement of lifting hooks with maximum load details etc. • Shall furnish the floor finishing requirement i.e., epoxy, flooring, hardonite etc.
2	All interface issues related to tunnel	Shall interface with PST Contractor and factor in the relevant requirements in UG tunnel civil/structure designs	Shall communicate the requirements of: <ul style="list-style-type: none"> • Cable path, gallery size, route alignment and mounting requirements requirement for various cables in the tunnel • Equipment ingress / egress route requirements • Earthing, bonding and stray current mitigation related requirements • Designs / drawings showing arrangement of Earth terminals required to be provided on piers, pedestals, segments, parapet etc. and the extent of welding required to be done on Reinforcement bars • Size and locations where the openings / cutouts are required in viaduct structures • Way side disconnection switches in tunnel • Signage boards for HV equipment

Item No.	Item Description	UG Civil Contractors	Power Supply & Traction (PST) Contractor
3	Space availability (tunnel)	UG Contractor shall study the alignment with chainage and space availability in the Tunnel and design PST and PS SCADA cable containments / brackets / trunking / trench in tunnel	PST Contractor shall specify Size and space in the Tunnel for the PST and PS SCADA cable containments / brackets / trunking / trench
4	Combined services drawings	Shall prepare the combined services drawings (CSD) in time required for the cable layout / routing / Laying within the Station and cable crossing at stations	Shall provide inputs to combined services drawings (CSD) for detailed cable (for duct bank / cable trays / Cable troughs / Cable shafts and etc.) layout / routing / Laying [HV and LV cables crossing to be avoided] within the Station and cable crossing at stations
C&I Stage			
Stations			
5	Cable installation program	Shall plan accordingly to meet the requirement	PST Contractor shall give the cable installation / Laying program Including starting and finishing chainage
6	ASS/TSS Room / Building	<ul style="list-style-type: none"> Shall construct ASS/TSS room / building to be requirement of the PST Contractor Shall ensure that no expansion joints are provided on the roof above ASS and ASS/TSS room Shall design floor for loads as furnished by the PST Contractor Shall provide necessary foundations for transformers, panels, other equipment etc. Shall provide the necessary cutouts for cables entry and exit from track level to the room Loading / unloading platform with lifting hooks to be provided as per requirement of PST Contractor. Proper removable / detachable barricade railings for loading & unloading platform to be provided in consultation with PST Contractor No emergency stair case should infringe the loading / unloading platform or affect movement of materials 	<ul style="list-style-type: none"> Shall jointly inspect and takeover the ASS/TSS room in coordination with Civil Contractor Shall coordinate with station building Contractor to ensure that no expansion joints are provided on the roof above ASS and ASS/TSS rooms Shall coordinate for the room size and other associated requirements Shall furnish the equipment weight and size details to station building Contractor for designing floor for appropriate load Should ensure height of the rolling shutters are adequate for pushing in the tallest equipment
7	Equipment access	UG Station Contractor shall consider the requirements pertaining to access for lifting facilities and easy maintenance for Electrical equipment in close Co-ordination with PS Contractor	PS Contractor shall co-ordinate with UG Station Contractor to design best access for lifting facilities for electrical machineries / plants / equipment for installation and easy maintenance wherever required
8	Site access	Site will be cleared free from obstacles and handed over for cable laying works	Space should be free of obstacles at the time of cable laying Works
9	Installation of 33 kV, 750V dc cables, traction return	<ul style="list-style-type: none"> Shall provide suitable opening and HDPE pipe for carrying cables inside ASS/TSS, for ETS and at track crossings as per requirement. The mounting 	<ul style="list-style-type: none"> Shall supply & install 33 kV, 750V dc cables, traction return cables, ETS cables, SCADA cables for ETS connection and other cables

Item No.	Item Description	UG Civil Contractors	Power Supply & Traction (PST) Contractor
	cables, ETS cable and control cable	<p>arrangement of ETS has to be provided in consultation with PST Contractor.</p> <ul style="list-style-type: none"> • Shall take into consideration the bending radius of cable and covering of cables in public places. • Station Building Contractor shall provide suitable opening in the TSS/ASS room at appropriate location for raising the cables coming from RSS/TSS at ground to the ASS/TSS by providing a shaft from ground to the TSS/ASS room. 	<ul style="list-style-type: none"> • Shall furnish the detailed cable schedule • Shall interface with the Station Contractor for the cable path for 33kV, 750V cables, traction return cables and SCADA cable for ETS connection in the station area • Shall co-ordinate with Station Contractors for provision of opening and HDPE pipes of adequate size to carry the cables inside ASS/TSS/ETS and at track crossings. • Shall close the opening with fire/water tight EPDM separators after installation of the cables • Shall coordinate with Station Building Contractor for suitable opening in the TSS/ASS room at appropriate location for raising the cables coming from RSS/TSS at ground to the ASS/TSS. Shall coordinate with civil Contractor for providing a shaft from ground to the TSS/ASS room.
10	Temporary Power for Installation, testing & commissioning	Shall provide sockets for availing temporary power, at main DC of if available, inside ASS/TSS rooms as per requirement	<ul style="list-style-type: none"> • Shall co-ordinate with Station Contractor for provision of temporary power and lighting • Shall provide suitable meters for calculating the consumption • Shall advise temporary power demand & required capacity and provide temporary cable • Shall install the required DB with all safety features for availing the temporary power • Shall pay to the Station Contractor for the power consumption <p>Note: If temporary power is not available from Station Contractor, then PST Contractor shall make his own arrangement.</p>
11	Installation of Equipment in ASS/TSS	<ul style="list-style-type: none"> • Shall construct ASS/TSS rooms keeping in view the specific requirements of PST Contractor regarding passages, ingress / egress routes, door size, knock out panels, floor openings etc. for access of heavy equipment forming permanent works • Shall provide cut-outs in floor / roof / walls for cable entry to the requirements of PST Contractor. 	<ul style="list-style-type: none"> • Shall provide dimensions and weights of various equipment • Shall supply, transport and install ASS/TSS Equipment including Transformers, 33kV Switchgear, Traction Transformers, Rectifiers, HSCB, Distribution Boards etc. as per Specifications.

Item No.	Item Description	UG Civil Contractors	Power Supply & Traction (PST) Contractor
		<ul style="list-style-type: none"> Shall make provision for passage/crossing of various cables in the station along the walls, under the platform copings etc. for cable entry from viaduct cable duct to ASS/TSS room. Shall provide hatch, gantry beams and loading deck for carrying heavy equipment and materials to substations. Shall provide lifting hooks in ASS/TSS rooms as per requirements of PST Contractor. 	<ul style="list-style-type: none"> Shall provide equipment layout drawing. Shall provide necessary foundations for transformers, panels other equipment etc. Alternatively, the Contractor can provide suitably designed anchor-fasteners to fix transformers, 33kV panels, Battery chargers etc. to the basic floor/pedestal Shall coordinate with Station Contractors for suitable design of ASS/TSS rooms to ensure smooth passage for carrying the equipment inside ASS/TSS. Shall coordinate with Station Contractors for suitable openings for cable and earthing connections and cable entry from tunnels to ASS/TSS room. Shall confirm the fire safety provisions Shall arrange material handling equipment at his own cost
12	Earthing, bonding and stray current mitigation arrangements at stations	<ul style="list-style-type: none"> Shall coordinate for requirements of stray current monitoring scheme Shall associate with PST to verify the earthing-bonding of structure as per approved scheme. Shall provide structure earth terminals Shall connect various structures at station to Earth Cable as per schematic 	<ul style="list-style-type: none"> Shall provide schematic arrangement of earthing, bonding and stray current protection management in the stations Shall connect Structure Earth Cable (SEC) to MET in ASS/ ASS+TSS
13	Earthing in ASS/TSS	Shall Supply and install the earth mat according to approved design furnished.	<ul style="list-style-type: none"> Shall associate during the installation of earth mat. Shall jointly check the resistance of the earth mat after installation.
14	Emergency Trip System (ETS) Installation	Shall provide niche / fixing arrangements in walls of stations or mounting arrangement on the walls/ pillars to accommodate ETS equipment and cables	<ul style="list-style-type: none"> Shall inform about the requirement of ETS Shall coordinate for locations of ETS at stations as well as cable routing from RTU in TSS/ASS room to ETS locations Shall provide ETS equipment at stations, cross passages and other appropriate locations including TSS and SCR room Shall install PLC cable from nearest ASS, ASS+TSS to ETS equipment
15	33 kV, 750 V dc, return cables and control cables from TSS to Station / mainline tracks (for	Provide embedded HDPE pipes for cable routes within the station area and building	<ul style="list-style-type: none"> Construct cable support, brackets, provide and lay all cables from RSS up to station and mainline boundary/shaft in station area and building.

Item No.	Item Description	UG Civil Contractors	Power Supply & Traction (PST) Contractor
	TSS not located within station building)		<ul style="list-style-type: none"> Coordinate for cable routes within the station area and building
16	Temporary storage	Shall study the space availability in the station and provide accordingly	Shall request the temporary storage area in the station building
17	Working space	Shall arrange Space free from human interference and materials	Shall request Space free from human interference and materials
18	Joint procedure	Validate and accept joint Maintenance procedure with PST Contractor	Prepare joint maintenance procedures in consultation with UG Contractor and shall jointly agree and accept
Tunnels			
19	Cable installation program	Shall plan accordingly to meet the requirement	PST Contractor shall give the cable installation / Laying program Including starting and finishing chainage
20	Equipment access	UG Contractor shall consider the requirements pertaining to access for lifting facilities and easy maintenance for Electrical equipment in close Co-ordination with PST Contractor	PST Contractor shall co-ordinate with UG Contractor to design best access for lifting facilities for electrical machineries / plants / equipment for installation and easy maintenance wherever required
21	Site access	Site will be cleared free from obstacles and handed over for cable laying works	Space should be free of obstacles at the time of cable laying Works
22	Installation of 33 kV, 750 V cables, return cables, control cables and other cables in the tunnels	<ul style="list-style-type: none"> To give marking for the space in tunnels and station area for cable laying Shall coordinate and allow PST Contractor to install suitable cable support infrastructure (metallic brackets, clamps, cable trays etc.) in the tunnels, as per requirement for laying of cables. Shall provide suitable opening at appropriate location for routing/laying of cable as per the requirements of PST Contractor 	<ul style="list-style-type: none"> To coordinate for area of cable laying in view of the walkway and track etc. Shall supply & install 33 kV, 750 V cables and return cables and any other cables in the tunnels including cable support infrastructure (trays, brackets, clamps etc.) Shall take into consideration the bending radius of cable and covering of cable in public places
23	Earthing, bonding and stray current mitigation arrangements in the tunnels	<ul style="list-style-type: none"> Shall incorporate earthing, bonding and stray current management requirements Shall provide structure earth terminals of tunnel structure for connecting them to Earth Cable Shall coordinate with PST Contractor for verification of earthing bonding and stray current measures adopted in the structure, as per the recommendations in approved design. The Tunnel Contractor shall provide the necessary earth terminals (including holes) for fixing cable lugs on handrail/walkway at expansion joint location (Including any discontinuity) for connection of cable 	<ul style="list-style-type: none"> Shall provide schematic arrangement of earthing, bonding and stray current protection management in the tunnels & ensure and certify that earthing, bonding and stray current management scheme is Implemented. Shall provide schematic of structure earth terminals, stray current collection mesh in track slab Shall supply and install Structure Earth conductor (SEC) and support/brackets including clamp (both UP and DN direction, including the station area

Item No.	Item Description	UG Civil Contractors	Power Supply & Traction (PST) Contractor
		& subsequent connection to Structure earth cables (SEC) as per drawings <ul style="list-style-type: none"> To implement the stray current arrangement as per PST GFC drawings 	<ul style="list-style-type: none"> Shall install and connect structure earth terminals of tunnel structure to SEC through cable as per specification Shall connect various structures (like handrail, walkway etc.) in tunnels to Structure Earth Cable as per schematic Shall coordinate with Tunnel Contractors for verification of earthing bonding and stray current measures adopted in the structure, as per the recommendations in approved design. Shall provide typical drawings showing arrangement of earth terminal required to be provided for earthing and bonding of the hand rail / walkway Shall Connect Hand Rails / walkway with SEC
24	Buried pipes for cables crossing tracks	Shall provide pipes buried in concrete as per design provided by PST Contractor and seal them temporarily.	<ul style="list-style-type: none"> PS Contractor will prepare a list of locations where buried pipes are to be provided. PS Contractor will remove seals at appropriate time and use the buried pipes for cable crossing. The pipes over the viaduct / parapet shall be supplied and installed by the PST Contractor
25	Warning and indicator boards	Shall provide suitable space for fixing third rail indicator boards in tunnels	<ul style="list-style-type: none"> Shall coordinate and inform locations of third rail warning and indicator boards Shall furnish the relevant drawings Shall review the fixing arrangement Shall supply and install all warning and indicator boards
26	Signages	Signage for all technical rooms should be made ready and shall be Co-operated / coordinated with PST Contractor	Shall jointly check the signage provided for all the technical rooms and to be confirmed
27	Third rails and disconnection switches	Shall provide suitable access for transport of third rails in tunnels Shall coordinate for installation of disconnection switches in tunnels	Shall coordinate for delivery of third rails in tunnels Shall provide and install disconnection switches on viaduct as per requirements.
28	Temporary storage	Shall study the space availability in the tunnels and provide accordingly	Shall request the temporary storage area in the tunnels
29	Working space	Shall arrange Space free from human interference and materials	Shall request Space free from human interference and materials
	T&C Stage		

Item No.	Item Description	UG Civil Contractors	Power Supply & Traction (PST) Contractor
30	Earthing and bonding arrangements in tunnels	Shall associate with PST Contractors for verification of earthing and bonding measures adopted in the structure, as per the recommendations in approved design. Shall jointly sign the records.	Shall undertake verification of earthing and bonding measures adopted in the structure, as per the recommendations in approved design. Shall lead the process and sign the records.
	Maintenance Stage		
31	Nil		

3.1.9 INTERFACE WITH PSD/PSG CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions apply as for elevated stations – refer [Para 2.1.9 above](#)

3.1.10 INTERFACE WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions apply as for elevated stations – refer [Para 2.1.10 above](#)

3.1.11 INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions apply as for elevated stations – refer [Para 2.1.11 above](#)

3.1.12 INTERFACE WITH ESCALATOR CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions apply as for elevated stations – refer [Para 0 above](#)

3.1.13 INTERFACE WITH TRACKWORK (TRW) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions apply as for elevated stations – refer [Para 2.1.13 above](#)

Additionally, the following apply:

Item No.	Subject	UG Civil Contractor	Track work (TRW) Contractor
	C&I Stage		
1	Temporary lighting & Power for Construction of track work	Shall provide temporary lighting & power in tunnels till commissioning of permanent lighting and power in tunnel.	Shall co-ordinate.
2	Survey Control Points inside the tunnels	To ensure the control points inside the tunnels are not obstructing for provision of fixtures by other designated Contractors. All the control points should be made available till the completion of the track work.	Shall co-ordinate.
3	Cutouts and access	Contractor to make available the agreed cutouts till all the works completed and plant & machineries are taken out from the tunnels. Provide access to these cutouts at all times from the approach roads.	Shall co-ordinate.

3.1.14 INTERFACE WITH TVS CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	UG Civil Contractor	TVS Contractor
	Design Stage		

Item No.	Subject	UG Civil Contractor	TVS Contractor
1	Station layouts, tunnel dimension, tunnel ventilation system, environmental control system, equipment sizing etc.	<ul style="list-style-type: none"> Shall provide updated details of station layouts, tunnel dimension, tunnel GAD, fire egress analysis for station and tunnel, cross passages, crossover, niche, ramp etc. for input into SES & CFD simulation Shall produce CSD taking into account the requirements of the TVS DDC/Contractor data provided by the SES simulation. Shall accommodate the TVS, TES, TVS Electrical panel room sizes and shafts (TVS+TES) and associated finishes. Shall provide the CSD as per the TVS Contractors requirements 	<ul style="list-style-type: none"> Shall provide input data for the tunnel ventilation system, equipment sizing & requirements, fans, damper, nozzles, niche, shafts etc. Shall provide TVS major equipment sizing, to enable maximum sizing at the station Shall confirm the equipment sizing, room sizes, room and shaft finishes, shaft dimensions, OTE openings, under platform exhaust Shall review the design from UG Civil Contractor as per CSD and specifications
2	TVS equipment including supports and brackets, install cables, TVS rooms	<ul style="list-style-type: none"> Shall produce station/tunnel layout/CSD drawings based on data provided by the TVS Designer/Contractor to accommodate the requirements for the TVS systems Shall finalize CSD based on detailed inputs from the TVS Designer/Contractor Shall provide structural details to the TVS Designer/Contractor to enable design of fixings and supports for the TVS equipment Shall incorporate the equipment load and dimensions provided Shall prepare CSD based upon the input given by TVS Contractor Shall consider the details for structural design as needed 	<ul style="list-style-type: none"> Shall provide detailed equipment dimensions, plenum areas, cut- out/hatch dimensions required, hooks, shafts sizes, duct openings, pull pits, maintenance cut-out and cabling requirements for the completion of the station input for inclusion in CSD Shall provide equipment layout along with dimensions for sizing of the equipment rooms/building Shall design fixing, supports and plinths for TVS equipment/panels for coordination with structural designs Shall provide the equipment load & dimensions for input for design of knock down panel / demountable wall for movement of equipment during maintenance/replacement. Shall review CSD based upon the input given by UG Contractor Shall provide the details of pressure effects on Cross Passage doors in tunnel induced by train piston effect
C&I Stage			
3	Equipment rooms	Shall complete construction of all TVS rooms, Over Track Exhaust, Under Platform Exhaust shaft, TVS/TES shafts, pull pits, etc., for TVS Contractors	Shall install TVS equipment including supports and brackets in the locations defined in the CSDs

Item No.	Subject	UG Civil Contractor	TVS Contractor
		with complete room finishes for installation of the TVS/TES equipment as per CSDs	
4	Equipment installation	Shall provide hand rails for tunnel ventilation horizontal dampers Shall provide required cut-out/hatch for equipment lowering	<ul style="list-style-type: none"> Shall co-ordinate. Shall coordinate and ensure that the provided cutout / hatch area sufficient for equipment lowering Shall supply, installation of cables and cable support infrastructure like cable trays, trunking and raceways etc., as required for completion of the work
5	Equipment access	<ul style="list-style-type: none"> Shall provide suitable road access for lowering the equipment Shall provide suitable access doors for all TVS equipment Shall close all the cutouts related with nozzle, damper etc. with masonry / concrete as per requirement 	<ul style="list-style-type: none"> Shall coordinate and ensure that the access roads and access doors etc. are adequate for lowering the equipment and installation of equipment Shall close all floor and wall openings (including unused floor & wall opening specifically provided for TVS equipment) provided by Civil Contractor with fire rated material after installation of all TVS related cable openings and electrical panel openings
6	Equipment foundation	Shall complete plinths/pedestal/ foundation as required for TVS equipment	Shall provide the details and monitor
7	Closing the openings	Shall close all cut-outs related with nozzle, damper etc., with masonry/concrete as per requirement	Shall provide the details and monitor
8	Equipment room finishing	Shall finish the floors with Epoxy paint and walls with anti-dust paint for TVS room. TES room, TVS shafts and TES shafts as per CSD	Shall provide the details and monitor
9	Water supply and drain points	<ul style="list-style-type: none"> Water supply provided through one point of connection and floor drain provided through plant room floor drains Shall provide and execute adequate drain points connected to main sump in TVS plant room, plenums shafts 	<ul style="list-style-type: none"> Shall connect water supply pipe line connection, floor drain with grating for Tunnel Ventilation equipment rooms etc. Shall coordinate
10	Access dates	Access Dates for TVS plant room, TES plant room, Nozzle Area, Portals/ramp areas, Tunnels, Shafts (TVS + TES) etc. to be provided	Shall get the details of the Access Dates and to accommodate in the Installation
11	Storage area	Shall provide storage space and advise access period to the TVS Contractor to transport material to site	Shall transport their material to site in interface with Civil Contractor in a specified space and period so that the construction activities after the access period are not hampered
	T&C Stage		

Item No.	Subject	UG Civil Contractor	TVS Contractor
12	TVS system testing and commissioning	Shall cooperate and support the testing and commissioning activities of the TVS system	Shall lead the testing and commissioning activities of TVS system
	O&M Stage		
13	TVS system O&M	Shall cooperate and support the O&M activities of the TVS system	Shall lead the O&M activities of TVS system

3.1.15 INTERFACE WITH ECS CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	UG Civil Contractor	ECS Contractor
	Design Stage		
1	Station layouts, tunnel dimension, tunnel ventilation system, environmental control system, equipment sizing etc.	Shall provide updated details of station layouts including ancillary building, fire egress analysis for station for input into ECS& CFD simulation	Shall provide input data for the Environmental control system, equipment sizing & requirements (i.e., Chiller plan room, chiller pump rooms, AHU plant rooms), fans, damper, shafts, associated equipment layouts etc.
2		Shall produce CSD taking into account the requirements of the ECS DDC/Contractor data provided by the simulation.	Shall provide ECS major equipment sizing, to enable maximum sizing at the station
3		Shall provide the CSD as per the ECS Contractors requirements	Shall review the design from UG Civil Contractor as per CSD and specifications
4	ECS and Chiller plant equipment including supports and brackets	Shall produce station layout drawings based on data provided by the ECS Contractor to accommodate the requirements for the ECS equipment	Shall provide detailed equipment dimensions, cut-out/hatch dimensions required, hooks, shafts sizes, drain point provisions, duct openings, pull pits, maintenance cut-out and cabling requirements for the completion of the station input and the CSD
5		Shall finalize CSD based on detailed inputs from the ECS Contractor.	Shall provide equipment layout along with dimensions for sizing of the equipment rooms/building
6		Shall provide structural details to the ECS Contractor to enable design of fixings and supports for the ECS equipment	<ul style="list-style-type: none"> Shall design fixing, supports and plinths for ECS and Chiller Plant equipment/panels for coordination with structural designs Shall provide the equipment load & dimensions for input for design and maintenance of equipment movement
7		Shall prepare CSD based upon the input given by ECS Contractor	Shall review CSD based upon the input given by UG Civil Contractor

Item No.	Subject	UG Civil Contractor	ECS Contractor
8		Shall provide the louvers to the ECS shaft openings at the Ground level as per requirement.	Shall provide the louver details such as size, location, separation distance and pressure drop requirement for each of the shafts.
9		Shall provide the required details to ECS Contractor and make provision in false ceiling to match duct access cutouts.	Shall collect Reflected ceiling plans, false ceiling details, colour of the diffusers/grilles to locate the diffuser and grilles in public areas & equipment room. Shall share the location of access cut-outs in the ducts with Arch/Civil Contractor.
	C&I Stage		
10	Equipment rooms	Shall complete construction of all ECS and Chiller Plant rooms, shafts, plenum area, pull pits and spaces to ECS Contractors with complete room finishes and for installation of the ECS and Chiller Plant equipment with accessories as per CSDs	Shall install ECS and Chiller Plant equipment with all accessories for completion of the work including supports and brackets in the locations defined in the CSDs
11	Equipment installation	Shall provide drain points and suitable connectivity as per CSD Shall coordinate	<ul style="list-style-type: none">Shall utilize the provided drain points and terminate the FCU and equipment drainpipes accordingly.Supply, installation of cables and cable support infrastructure like cable trays, trunking and raceways etc., as required for completion of the work
12	Equipment access	<ul style="list-style-type: none">Shall provide required cut- out/hatch for equipment loweringShall provide suitable access doors for all ECS equipment	<ul style="list-style-type: none">Shall coordinate and ensure that the access roads and access doors etc. are adequate for lowering the equipment and installation of equipment.Shall close all floor and wall openings including unused floor & wall opening specifically provided for ECS equipment) provided by Civil Contractor with fire rated material after installation of all ECS equipment
13	Equipment foundation	Shall provide suitable road access for lowering the equipment	Shall lower the equipment in the designated access cutout
14	Closing the openings	Shall complete plinths/pedestal/ foundation as required for ECS & Chiller Plant equipment	Shall monitor
15	Equipment room finishing	Shall finish the floors, shafts with Epoxy paint and walls with anti-dust paint as per CSD	Shall monitor
16	Temporary power for installation, testing and commissioning	<ul style="list-style-type: none">Shall provide temporary power as per requirementShall provide suitable meters for calculating the consumption	<ul style="list-style-type: none">Shall co-ordinate with UG Contractor for provision of suitable sockets for temporary powerShall provide required cables and distribution boardsShall pay to UG Contractor for the power consumption

Item No.	Subject	UG Civil Contractor	ECS Contractor
17	Storage facilities and utilization of access period for transportation of material to site	<ul style="list-style-type: none"> Shall provide storage space and advise access period to the interface Contractor to transport the material to site 	<ul style="list-style-type: none"> Shall transport their materials to site in interface with UG Contractor in a specified space and period so that the construction activities after the access period are not hampered
18	Access dates	<ul style="list-style-type: none"> Access dates for ECS rooms, ECS Shafts, Ancillary Building, Concourse & Platform, both areas to be provided 	<ul style="list-style-type: none"> Shall get the details of the Access Dates and to accommodate in the Installation.
19	Storage area	Shall provide storage space and advise access period to the ECS Contractor to transport material to site	Shall transport their material to site in interface with Civil Contractor in a specified space and period so that the construction activities after the access period are not hampered
	T&C Stage		
20	ECS system testing and commissioning	Shall cooperate and support the testing and commissioning activities of the ECS system	Shall lead the testing and commissioning activities of ECS system
	O&M Stage		
21	ECS system O&M	Shall cooperate and support the O&M activities of the ECS system	Shall lead the O&M activities of ECS system

3.1.16 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 2.1.14 above](#) shall apply as relevant to the context

CHAPTER 4

4.0 DEPOT CONTRACTORS' INTERFACES

4.1.1 INTERFACE WITH DESIGNER / DESIGN WING / CONSULTANTS

The Contractor is responsible for coordinating and interfacing with following:

- (i) Detailed Design Consultants if engaged by BMRCL for various reaches / sections
- (ii) In-house Design Wing of BMRCL
- (iii) Agency which BMRCL has engaged for preparation of project DPR
- (iv) Survey agency engaged by BMRCL
- (v) Geo-tech investigating agency engaged by BMRCL
- (vi) Any other design agency / consulting agency engaged by BMRCL which has relevance for Contractor's work

4.1.2 INTERFACE WITH UTILITY AGENCY

The Contractor is responsible for coordinating and interfacing with following agencies:

- (i) BBMP
- (ii) BWSSB
- (iii) BESCOM
- (iv) Other utilities / civic agencies
- (v) Karnataka State Fire & Emergency Services
- (vi) Any other Statutory Authorities

4.1.3 INTERFACE WITH DEPOT E&M CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Depot Civil Contractor	Depot E&M Contractor
	Design Stage		
1	All Depot Buildings, Ancillary Buildings, Service Galleries Interfaces	<ul style="list-style-type: none"> Final Sizes of all the Structural members like Columns, Beams and Structural Slabs to be worked out in consultation with E&M DDC/Contractor and based on the Preliminary layout prepared 	<ul style="list-style-type: none"> Details of all the cut-outs for all the services in the Depot and other structural members Provisions for specific arrangements in the structural design to meet systems/design requirement

Item No.	Subject	Depot Civil Contractor	Depot E&M Contractor
		<ul style="list-style-type: none"> All the provisions specified by the designated Systems Contractors and E&M DDC/Contractor to be kept in the structural design. 	<ul style="list-style-type: none"> Final layout and detailed cross-sections of the Depot area including ancillary building and service galleries incorporating final dimensions of the structural members in consultation with the Designated Contractor...
2	Equipment rooms, sumps, conduit and ducts	<ul style="list-style-type: none"> Shall incorporate input from the E&M Contractor in the production of Structural E&M drawings (SEM) that will show all the necessary openings, cut-outs, hatch, core cutting, plinths, foundations etc. for E&M equipment Shall provide input for dewatering and domestic water pipeline etc. for route drawing in depot. Shall review the CSD and SEM as and when required. 	<ul style="list-style-type: none"> Shall provide design of all E&M equipment, sizing, weight, layouts etc. Shall provide input for deciding room sizes at depot buildings to Civil Contractor. Shall prepare equipment, cable, raceways, trunking, , dewatering pumps, fire hydrant, and domestic water pipeline etc., route drawing in depot buildings. Shall provide input for SEM drawings and the inputs on requirement of cable shaft, shaft opening details, floor cut-outs, pull pits etc., Shall review CSD and SEM as and when required.
3	Cable trench, pulpits	The Depot Civil Contractor shall design and provide all external and internal cable trenches, trench covers / cement slabs / chequered plates, cable pull chambers, as per requirement of E&M and other system Contractors in the depot	The E&M Contractor shall provide the dimensions of width and depth of external cable trenches, cable pull chambers with details of concrete cover / cement slabs / chequered plates on trenches for complete length in depot for laying power & control cables (including details of necessary channels, GI angles, other accessories for supporting cables / cable trays at standard spacing within cable trenches)
4	Overhead cranes	The Depot Civil Contractor shall design the EOT crane drawings in RBL, inspection bay, pit wheel lathe shop, engineering train unit / shed etc. required for erection of overhead cranes. The Depot Civil Contractor shall include in the drawings for details of supporting structures / beams / gantries required for erection of overhead cranes	The E&M Contractor shall provide the power supply required for EOT cranes as per the requirement
5	Lifts	The Depot Civil Contractor shall design the necessary pits for lift, lift shaft, hooks, and area for control panel, for the buildings where the lift provision is made in coordination with E&M Contractor	The E&M Contractor shall provide the details of dimensions of lift, lift shaft and shall incorporate the requirement of lift pits, hooks, lift shaft in the drawings including lift machinery / control panel location details
	C&I Stage		
6	Equipment rooms, sumps, conduit and ducts	<ul style="list-style-type: none"> Complete equipment rooms such as OCC, DCC, sheds, ancillary building, sumps and other spaces 	<ul style="list-style-type: none"> Shall install E&M equipment as required in the E&M scope of works at location provided by the Depot Contractor.

Item No.	Subject	Depot Civil Contractor	Depot E&M Contractor
		for the installation of the E&M equipment such as pumps, DGs, control panels etc., <ul style="list-style-type: none"> • Provide structural openings, construction of plinths/foundations, embedded conduits, sleeves for use of E&M Contractor as per SEM. • Shall provide suitable road access for loading/unloading of the equipment. • Installation of embedded discharge pipe up to discharge level outlet for de-watering and domestic pumps 	<ul style="list-style-type: none"> • Shall provide raceways, trunking for the E&M works and other system Contractor for all routes defined in the CSDs. • Shall close all floor and wall openings provided by Civil Contractor with suitable fire rated material after installation of all E&M services related to their work. • Installation of dewatering pumps along with embedded discharge pipe up to discharge level outlet.
7	Temporary power for installation, testing and commissioning	Shall provide temporary power as per requirement	<ul style="list-style-type: none"> • Shall co-ordinate with Civil Contractor for provision of suitable sockets for temporary power. • Shall provide suitable meters for calculating the consumption • Shall provide required cables and distribution boards. • Shall pay to civil Contractor for the power consumption. <p>Note: If temporary power is not available with Civil Contractor, then the E&M Contractor shall make his own arrangement for the same.</p>
	T&C Stage		
8	Nil		
	O&M Stage		
9	Nil		

4.1.4 INTERFACE WITH DEPOT FINISHING CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Depot Civil Contractor	Depot Finishing Contractor
	Design Stage		
1	Depot building design including all areas and equipment rooms	Design and coordination with Finishing Contractor	Furnish the requirements related to Finishing Works for incorporation in the designs

Item No.	Subject	Depot Civil Contractor	Depot Finishing Contractor
	C&I Stage		
2	Depot construction including all areas and equipment rooms	Civil and structural construction of the depot as per agreed designs duly in coordination with Finishing works Contractors as well as other designated Contractors	Finishing works of the depot buildings as per scope of work in coordination with Civil Contractor as well as other designated Contractors
	T&C Stage		
3	Nil		
	O&M Stage		
4	Nil		

4.1.5 INTERFACES WITH SIGNALING& TRAIN CONTROL (S&TC) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Depot Civil Contractor	S&TC Contractor
	Design Stage		
1	Layout of rooms at the depot – SER / CER, UPS room and Depot control rooms	Prepare and furnish depot drawings; Incorporate room requirements including shafts/cut outs/pipes etc. as furnished by S&TC Contractor. Provision of trenches in S&T UPS Room.	<ul style="list-style-type: none"> Furnish layout of S&TC equipment within OCC, Depot Control Centre etc. in close coordination with the civil DDC and/ or construction Contractor. Mark cable trays on the drawings in close coordination with the DDC / Civil Contractor. Review design with the DDC / Contractor. Co-ordinate closely with Construction Contractor to ensure the requirement at site are met.
2	Cable support infrastructure in the depot	Design the concrete duct banks / hangers / trays for main cables into the Building & Civil works for main Signalling cables throughout the depot. Fiber optic cables shall have route diversity. Design details to be resolved in the interface with designated Contractors for design requirements. Provision of space for line side equipment.	<ul style="list-style-type: none"> Review/ mark the requirement of concrete cable ducts for main cables including track / road crossings for Signalling cables throughout the Depot area. Furnish and confirm sizes and bending radius of main cable duct and cross track cable ducts for main cables in close coordination with the civil design and / or construction Contractor. Review the design from detailed design Contractors and closely coordinate with construction Contractor to ensure that the requirements at site are met.
3	Track side equipment for Signalling	Shall interface for design requirements and provide the required space for line side equipment for the depots	Furnish locations of line side equipment

Item No.	Subject	Depot Civil Contractor	S&TC Contractor
4	Depot Control Center	Incorporate design requirement of S&TC Contractor in the DCC room viz. Space for workstations / and other S&TC equipment etc.	Furnish layout of S&TC equipment within Depot Control Center for S&TC equipment in close coordination with the civil design and/ or construction Contractor.
5	Test Track	Shall coordinate with S&TC Contractor (and track Contractor for this item)	S&TC Contractor shall install all the ATP equipment, required for the test track at the depot
	C&I Stage		
6	Layout of rooms at the Depot: Signalling Equipment room (SER), UPS, Signalling maintenance room, and Depot control room (DCR).	Construct the rooms as per the design, providing cut outs, shafts, false flooring, false ceiling, fire rated doors, cable trenches for S&T UPS Room, checkered plate for cable trench cover in UPS room etc. as required.	<ul style="list-style-type: none"> • Provide equipment foundations / pedestals / base frames. • Install all S&TC equipment, cables, cable trays under false floors etc. • Seal the gaps after cable installation work with fire resistant material.
7	Cable support infrastructure in the depot	Provide Masonry Cable ducts/cable pull pits including covers/Pipes if necessary, in depot	<p>Install cables for all Signalling systems including provision of all cable supports.</p> <p>Provide shielding of cables where necessary.</p>
8	Track side equipment for Signalling	Shall construct as per design finalized	Install all line side equipment including equipment foundations etc.
9	Depot Control Center	Construct the DCC as per approved design	Provide furniture for all Systems; provide UPS supply for workstations for all systems including suitable protection arrangement in UPS room and install Signalling equipment within Depot Control Centre including cable tray provision for Signalling equipment.
10	Test Track	Shall coordinate with S&TC Contractor (and track Contractor for this item)	S&TC Contractor shall install all the ATP equipment, required for the test track at the depot
	T&C Stage		
11	Nil		
	Maintenance Stage		
12	Nil		

Note: The provisions of [Para 0 above](#) regarding Earthing & Bonding applies for depot also as relevant to the context.

4.1.6 INTERFACES WITH ROLLING STOCK CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item no.	Subject	Depot Civil Contractor	Rolling Stock (RS) Contractor
Design stage			
1	Requirement for commissioning and testing of cars	Based on Engineer's / DDC's broad design and review of RS, DDC shall design the infrastructure facilities for commissioning and testing of cars in nominated Depot(s).	Review the planning by Engineer / DDC and define the minimum facilities required for commissioning and testing the cars in the depot.
2	Metro train Maintenance requirement	Shall design the Depot maintenance facilities including all depot buildings, to suit RS requirement	Shall furnish the maintenance schedules and equipment requirement for complete cars, assemblies and subassemblies systems and sub systems
3	Plant and Machinery, test panels, tools and instruments etc.	Depot Engineer shall design and develop specifications for supply and commissioning of General-purpose plant and machinery, tools and instruments at Depot. DDC/Depot Civil Contractor Shall Incorporate structural provision and electrical & mechanical provisions for all Machinery and Plant.	Provide details of all special tools / test panels suitable for the rolling stock testing, commissioning and maintenance.
4	Store facilities for important items of Rolling Stock.	Shall design the store facilities for assemblies, sub-assemblies, capital spares etc. at Depot.	Shall furnish the special requirements for storage and the quantities for storage
C&I Stage			
5	Requirement for commissioning and testing of cars	Shall construct the facilities for commissioning and testing of cars in nominated depot to meet the commissioning schedule of rolling stocks	Coordinate to ensure the minimum facilities required for commissioning and testing the cars in the depot are built timely
6	Metro train Maintenance requirement	Shall construct the facilities (except certain maintenance equipment) needed to meet the maintenance needs as advised by RS Contractor.	Coordinate to ensure the requisite maintenance facilities in the depot are built timely
7	Plant and Machinery, test panels, tools and instruments etc.	Incorporate structural provision and electrical & mechanical provisions for all Machinery and Plant.	Supply all special tools / test panels suitable for the rolling stock testing, commissioning and maintenance.
8	Store facilities for important items of Rolling Stock.	Shall construct the store facilities	Shall coordinate to ensure that the special requirements for storage are met
9	Central Depot Construction, Commissioning and Operational Readiness	To Liaise and coordinate with the RS Contractor to agree facility completeness and accessibility for car delivery to agreed delivery schedule as approved by BMRCL	Liaise and coordinate with the Construction Contract / DDC for car deliveries and access. Not to deliver cars in advance of agreed delivery schedule without agreement of DDC and approval of BMRCL.
T&C Stage			

Item no.	Subject	Depot Civil Contractor	Rolling Stock (RS) Contractor
10	Testing and commissioning	Shall jointly check and confirm the maximum noise / echo level with respect to various operating speeds of rolling stock	Shall co-ordinate and confirm with depot Contractor
11	Integrated testing	Shall coordinate with RS Contractor to complete testing and commissioning work	Require to conduct integrated test with all systems
	Maintenance Stage		
12	Nil		

4.1.7 INTERFACES WITH TELECOMMUNICATION (TEL) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	Depot Civil Contractor	Telecom Contractor
	Design Stage		
1	Layout of relevant equipment rooms at the depot / OCC / DCC	Prepare and furnish depot drawings; Incorporate room requirements including shafts/cut outs/pipes etc. as furnished by Telecom Contractor. Provision of trenches in UPS Room.	<ul style="list-style-type: none"> Furnish layout of Telecom equipment within OCC, Depot Control Centre etc. in close coordination with the civil DDC and/ or construction Contractor. Mark requisite requirements in close coordination with the civil design / construction Contractor. Review design with the civil design Contractor. Coordinate closely with construction Contractor to ensure the requirements at site are met.
2	Cable support infrastructure in the depot	Design the concrete duct banks / hangers / trays for main cables into the Building & Civil works for main Telecom cables throughout the depot. Fiber optic cables shall have route diversity. Design details to be resolved in the interface with designated Contractors for design requirements. Provision of space for line side equipment.	<ul style="list-style-type: none"> Review/ mark the requirement of concrete cable ducts for main cables including track / road crossings for Telecom cables throughout the Depot area. Furnish and confirm sizes and bending radius of main cable duct and cross track cable ducts for main cables in close coordination with the civil design and / or construction Contractor. Review the design from detailed design Contractors and closely coordinate with construction Contractor to ensure that the requirements at site are met.
3	Track side equipment for Telecom	Shall interface for design requirements and provide the required space for line side equipment for the depots	Furnish locations of line side equipment
4	Depot Control Center	Incorporate design requirement of Telecom Contractor in the DCC room viz. Space for workstations / and other telecom equipment etc.	Furnish layout of telecom equipment within Depot Control Center for telecom equipment in close

SN	Subject	Depot Civil Contractor	Telecom Contractor
			coordination with the civil design and/ or construction Contractor.
5	TETRA Radio Tower	Shall incorporate the requirement of radio tower at select locations	Shall provide design requirements for radio tower and shall coordinate appropriately
6	Construction and Installation	The structure design shall consider the mounting and fixing arrangements for heavy equipment like CCTV monitors, display boards, analogue clocks etc., as per the Telecom Contractor's requirements.	Shall furnish the requirements to civil Contractor
C&I Stage			
7	Layout of relevant equipment rooms at the depot / OCC / DCC	Shall construct rooms complete with structures, Shafts/cut outs in rooms for cable entry.	Construct all cable trays, risers etc. within the rooms required for Telecom System. Provide equipment foundations / pedestals. Install all Telecom equipment, cables etc. Seal the openings with fire resistant material after cable installation work.
8	Cable support infrastructure in the depot	Shall construct finishing works for main cables into the building & trenches / Cable ducts/cable pull pits including covers/Pipes if necessary, in depot	Shall lay the telecom cables for all Telecom systems
9	Track side equipment for Telecom	Shall construct as per design finalized	Install all line side equipment including equipment foundations etc.
10	Depot Control Center	Construct the DCC room as per approved design	Provide and install Telecom equipment within Depot Control Centre including cable tray provision for Telecom equipment.
11	TETRA Radio Tower	<ul style="list-style-type: none"> Shall construct the structure to enable installation of radio tower Tower foundation shall be constructed as per design provided by Telecom Contractor 	<ul style="list-style-type: none"> Shall verify the tower foundation jointly with Civil Contractor Shall install the radio towers
12	Construction and Installation	Shall install the mounting and fixing arrangements for heavy equipment like CCTV monitors, display boards, analogue clocks etc., during the construction as per the Telecom Contractor's requirements.	<ul style="list-style-type: none"> The fixtures will be to be designed and installed by Telecom Contractor. Primary Fixtures & Secondary Fixtures for Telecom equipment shall be provided by Telecom Contractor as per aesthetics of the building architecture. Sample to be get approved from BMRCL.
T&C Stage			
13	Nil		
Maintenance Stage			
14	Nil		

4.1.8 INTERFACES WITH POWER SUPPLY (PST) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Depot Civil Contractor	Power Supply & Traction (PST) Contractor
Design Stage			
1	All interface issues related to ASS/TSS building	<ul style="list-style-type: none"> Shall interface with PST Contractor and factor in the relevant requirements in ASS/TSS/station civil/structure designs and depot layout design Shall ensure that no expansion joints are provided on the roof above ASS and ASS/TSS room 	Shall furnish the requirements of: <ul style="list-style-type: none"> ASS/TSS rooms layout design Equipment ingress / egress route requirements Weight and dimension of cables Cable paths (ducts, trays, brackets etc.), gallery size, route alignment, mounting arrangement of cables, bending radii of cables Earthing, bonding and stray current mitigation related requirements ETS related requirements Approach road to ASS/TSS
2	All interface issues related to depot sheds & outdoor areas	Shall interface with PST Contractor and factor in the relevant requirements in viaduct civil/structure designs	Shall furnish the requirements of: <ul style="list-style-type: none"> Cable path, gallery size, route alignment and mounting requirements requirement for various cables Earthing, bonding and stray current mitigation related requirements Designs / drawings showing arrangement of Earth terminals Size and locations where the openings / cutouts are required in various structures Way side disconnection switches in depot ETS related requirements Stinger system in inspection bays and other bays as required
C&I Stage			
3	Installation of 33kV, 750V DC cables, ETS, traction return cables and control cables (from boundary of RSS/TSS complex and to various places in Depot such as ASS, workshop, third rails,	<ul style="list-style-type: none"> Shall construct cable trenches for carrying the cables from RSS complex to ASS/TSS and various third rail/ return rails in the depot area Shall coordinate and allow PST Contractor to provide and install cable support infrastructure (metallic brackets, trays etc.) inside the trench / cable duct as per requirement. 	<ul style="list-style-type: none"> Shall supply & install 33 kV, 750 V, ETS cables, traction return cables and control cables including cable support infrastructure (trays, brackets etc.). Shall co-ordinate and give requirements to the Depot Contractor for the cable trench and cable path for 33 kV, 750V dc cables, return cables and control cables in the Depot area

Item No.	Subject	Depot Civil Contractor	Power Supply & Traction (PST) Contractor
	ETS Disconnection switches etc.)	<ul style="list-style-type: none"> Shall provide suitable opening and HDPE pipe for carrying cables as per the requirement. Shall take into consideration the bending radius of cable and covering of cables at relevant places. 	<ul style="list-style-type: none"> Shall co-ordinate with Depot Contractor for provision of opening and HDPE pipes of adequate size to carry the cables
4	Temporary Power for Installation, testing & commissioning	Shall provide socket for availing temporary power, at main DB or if available, inside ASS/TSS rooms as per requirement	<ul style="list-style-type: none"> Shall co-ordinate with Depot Contractor for provision of temporary power. Shall provide suitable meters for calculating the consumption Shall advise temporary power demand & required capacity and provide temporary cable Shall install the required DB with all safety features for availing the temporary power Shall pay to the Depot Contractor for the power consumption. <p>Note: If temporary power is not available with Depot Contractor, PST Contractor shall make his own arrangement</p>
5	Masonry cable ducts inside ASS	Shall construct the cable ducts / trenches	Shall install cable brackets / trays inside the ducts
6	Installation of Equipment in Depot TSS / ASS	<ul style="list-style-type: none"> Shall construct ASS / TSS rooms keeping in view the specific requirements of PST Contractor (as per drawings) regarding passages, door size, knock out panels, floor openings etc. Shall provide ASS/TSS room complete in all respects, including flooring, access doors (2 doors about 2x3m with anti-panic system), rolling shutters, windows, ventilators and interior finish. Floor and walls shall be prepared with anti-dust paint. Shall provide cut-outs/trench in floor for cable entry. Shall provide suitable approach road to ASS / TSS 	<ul style="list-style-type: none"> Shall supply, transport and install ASS / TSS Equipment including Transformers, 33 kV Switchgear, etc. Shall provide necessary foundations for transformers, panels other equipment etc. Shall coordinate with Depot Contractor for suitable design of ASS / TSS rooms to ensure smooth passage for carrying the equipment inside ASS/TSS Shall coordinate with Depot Contractor for suitable openings/ trench in floor for cable and earthing connections. Shall coordinate for suitable approach road to ASS /TSS Shall arrange material handling equipment at his own cost

Item No.	Subject	Depot Civil Contractor	Power Supply & Traction (PST) Contractor
7	Earthing, bonding and stray current mitigation arrangements in depot	<ul style="list-style-type: none"> Shall provide necessary earth terminals, earth mesh etc. and risers and respect the schematic earthing drawing. Shall provide structure earth terminals Shall associate with PST to verify the earthing-bonding of structure as per approved scheme. Shall connect various structures in depot to Earth system as per schematic. 	Shall provide schematic arrangement of earthing, bonding and stray current protection management in the depot
8	Earthing of depot sheds, track support structure in inspection bay etc.	Shall provide / install earthing as per drawing under the floor or as required and connection to earthing stations.	<ul style="list-style-type: none"> Shall provide earthing schematic and drawings Shall supervise the earthing installation
9	Emergency Trip System (ETS) Installation	<ul style="list-style-type: none"> Shall provide niches/arrangement to accommodate ETS equipment and emergency telephone Shall provide cable route for PLC cable from SCADA RTU to ETS. 	<ul style="list-style-type: none"> Shall inform about the requirement of ETS Shall coordinate for locations of ETS at various locations in depot Shall provide ETS equipment at appropriate locations in depot Shall install PLC cable from nearest SCADA RTU to ETS equipment
10	Buried pipes for cables crossing tracks	Shall provide pipes buried in concrete as per design provided by PST Contractor and seal them temporarily.	<ul style="list-style-type: none"> PST Contractor will prepare a list of locations and size where buried pipes are to be provided. PS Contractor will remove seals at appropriate time and use the buried pipes for cable crossing. The pipes over the structures shall be supplied and installed by the PST Contractor
11	Third rails and disconnection switches	<ul style="list-style-type: none"> Shall provide suitable access for transport of third rails in depot. Shall coordinate for installation of disconnection switches in depot area. 	<ul style="list-style-type: none"> Shall coordinate for delivery of third rails in depot Shall provide and install disconnection switches in depot as per approved scheme
12	Power supply and SCADA rooms / spaces in depot	<ul style="list-style-type: none"> Shall provide space for SCADA server room, SCADA supervisor and maintenance room Floor and walls prepared with anti-dust paint. Each room to be provided with a door 2.5m with anti-panic system door. Provide access to various rooms / spaces Shall provide space for two workstations and LCD screen for power SCADA in OCC theatre. 	<ul style="list-style-type: none"> Shall coordinate for suitable space in OCC Shall supply and install equipment Shall provide requirement of space for SCADA equipment.

Item No.	Subject	Depot Civil Contractor	Power Supply & Traction (PST) Contractor
13	Installation of stinger system, in inspection bay, stabling shed, interior cleaning plant and emergency equipment building	Shall install the supporting structure for stinger suspension /bracket assembly on the brackets and drop arms fixed on trusses as per drawings	<ul style="list-style-type: none"> Shall furnish detailed interface drawings including the requirement of mounting plates on columns, drop arms fixed to the trusses, support for termination arrangement on beams /slabs etc. Shall supply and install bracket assemblies with fastening arrangement on columns and drop arms Shall supply and install cable support infrastructure (brackets, trays, etc.) for all control and power cables
	T&C Stage		
14	Earthing and bonding arrangements in depot areas	Shall associate with PST Contractors for verification of earthing and bonding measures adopted in the structure, as per the recommendations in approved design. Shall jointly sign the records.	Shall undertake verification of earthing and bonding measures adopted in the structure, as per the recommendations in approved design. Shall lead the process and sign the records.
	Maintenance Stage		
15	Nil		

4.1.9 INTERFACES WITH RECEIVING SUBSTATION (RSS) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Item Description	Depot Civil Contractor	RSS Contractor
1	Demarcation and process to take over the RSS land located inside depot.	Shall coordinate to land demarcation and provide the access to the RSS land.	Shall coordinate with depot Contractor to get the demarcation and RSS land.
2	Installation of all Cables originating from PSA substation (66kV/220 kV UG Cables from KPTCL GSSs).	Shall coordinate for all cable route in the depot boundary and provide access to RSS Contractor for construction work by RSS Contractor.	Shall supply and install cables including construction of all works related to cable trench, ducts, jointing bay etc., in the depot area
3	Temporary Power for Installation, testing & commissioning	Shall provide sockets for availing temporary power, at main DB or if available, inside equipment rooms as per requirement	<ul style="list-style-type: none"> Shall co-ordinate for provision of temporary power. Shall advise temporary power demand & required capacity and provide temporary cable. Shall provide suitable meters for calculating the consumption.

Item No.	Item Description	Depot Civil Contractor	RSS Contractor
			<ul style="list-style-type: none"> Shall install the required DB with all safety features for availing the temporary power. Shall pay to the Depot Contractor for the power consumption. <p>Note: If temporary power is not available from Depot, then RSS Contractor shall make his own arrangement.</p>

4.1.10 INTERFACES WITH PLATFORM SCREEN DOORS / GATES (PSD/PSG) CONTRACTOR

This interface will be applicable in case BMRCL decides to install PSD/PSG in depot (along test track) for system integrated testing and training purposes.

The interface responsibilities of respective Contractors shall be similar to that provided between Station Contractor and PSD/PSG Contractor under [Para 2.1.9 above](#).

Additionally, the Depot Contractor shall provide all civil structure for a mock-up at test track as per the drawings / requirements to be provided by PSD/PSG Contractor. This mock-up facility will be used by BMRCL for training purposes in future.

4.1.11 INTERFACES WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR

Definition and Scope

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item no.		Depot Civil Contractor	AFC Contractor
	Design stage		
1	Provision of rooms and areas for equipment layout	Shall incorporate the space and room requirements for AFC Equipment in the Depot. Incorporate the following AFC equipment rooms: - i) OCC Central Computer System ii) OCC Work Stations Room iii) CID/CPD, TOM Room iv) Software Development Centre (SDC) v) AFC Repair Workshop	Shall finalize the room schedule and layout for AFC Equipment at Depot. Furnish the room requirement & schedule for: - i) OCC Central Computer System ii) OCC Work Stations Room iii) CID/CPD, TOM Room iv) Software Development Centre (SDC) v) AFC Repair Workshop
2	Review of documents and drawings	Shall incorporate the review comments in the drawings and finalize the depot documentation	Shall review the drawings and documents for AFC requirements e.g.

Item no.	Depot Civil Contractor	AFC Contractor
3	SDC/OCC, Central Computer etc. (Depot Civil)	Design details to be worked out in interface with design requirements of AFC Contractor Location and number of equipment to be decided in consultation with AFC Contractor.
		1. Room schedule 2. Layout 3. Cable routing 4. Gate array etc. in SDC/PTR room (Not limited to above drawings and documents) Confirm basic equipment sizes and layout Furnish equipment sizes and weights Furnish equipment mounting details Confirm finishes Furnish requirement of cable trenches, cable routing and cable support provisions Review the design from designated Contractor
C&I stage		
4	SDC/OCC, Central Computer etc.	Construction of trenches for laying of Power and data / communication cables
5	Provision of rooms and areas for equipment layout	<ul style="list-style-type: none"> To construct the room and other area as per the AFC room schedule To provide the access to AFC Contractor for the installation of equipment
6	Mechanical and Structural Interfaces	To construct and provide civil and structural facilities required for AFC installation <ul style="list-style-type: none"> To check and confirm that AFC specific requirements for installation are made available To install the AFC electrical cabinet and do the cable termination To install the data switches and do the data cable terminations To do the internal wiring of AFC equipment at the AFC rooms at Depot To fix the AFC equipment at AFC rooms and complete the installation
7	Cable paths	Depot Contractor shall be responsible and coordinate to provide the facilities according to AFC Contractor requirements All provision of items related with civil i.e. Trenches, Wall Opening for Piping, Conduits and Cable for power & Data shall be laid by Depot Contractor
8	Review of documents and drawings	To review the as-built drawings and documents as per the documentation plan
9	Utilities required for site works	To provide the following utilities for installation of AFC equipment 1. Temporary power Temporary lighting at AFC rooms To avail for installation of AFC equipment 1. Temporary power 2. Temporary lighting at AFC rooms

Item no.		Depot Civil Contractor	AFC Contractor
10	Strategy at Site	To provide temporary storage space for the AFC equipment	To check the adequacy of the temporary storage space for AFC equipment
11	SDC/OCC (Depot E&M)	Installation of Computer / equipment Power & data cables for computer & equipment	Indoor and outdoor lighting, Air-conditioning, Power points for Station computer, Supply through UPS, Communication line for Station Computer,
T&C stage			
12		Depot Contractor shall comply and assist to AFC Contractor for the required testing and commissioning for works mentioned under Design, Supply and Construction stage under Depot Contractor responsibility	AFC Contractor shall submit to Depot Contractor the testing and commissioning requirements for items mentioned under Design, Supply and Construction stage
13		Depot Contractor shall be responsible and coordinate to provide the facilities according to AFC Contractor requirements	Depot Contractor shall submit equipment layout method statement, testing procedure and power load calculation of AFC equipment for testing activities should be done by AFC Contractor
Maintenance stage			
14	Nil		

4.1.12 INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions apply as for elevated stations – refer [Para 2.1.11 above](#)

4.1.13 INTERFACE WITH ESCALATOR CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions apply as for elevated stations – refer [Para 2.1.12 above](#)

4.1.14 INTERFACES WITH TRACKWORK (TRW) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Item Description	Depot Civil Contractor	Track work Contractor
Design Stage			
1	Depot Layout Drawing	Shall supply depot layout drawing and shall also supply detailed interface drawing of utility & depot construction	Shall design track work, based on depot layout drawing, maintaining the clearance based on interface drawing supplied
2	Track in Workshop, Inspection Bay, Stabling Lines, Washing Plant, Blow down plant. Pit wheel lathe, Engineering Train Unit (ETU) and other areas of depot	Shall supply depot layout drawing and shall also supply detailed interface drawing of utility & depot construction	Shall furnish the designs of tracks in Workshop, Inspection Bay, Stabling Lines, Washing Plant, Blow down plant. Pit wheel lathe, Engineering Train Unit (ETU) and other areas of depot
3	Provision of transition slabs between ballast less track on ramp and ballasted track at-grade in depots	Shall design the slabs	Shall furnish the details such as slab top level, ballast, retaining wall etc., enabling Depot Contractor to undertake the detailed structural design
C&I Stage			
4	Installation of track in Workshop, Inspection Bay, Stabling Lines, Washing Plant, Blow down plant. Pit wheel lathe, Emergency team building and other areas of depot.	<u>Ballasted track</u> Prepare the formation with grading and drainage, take care that all pipes and culvert crossing are laid.	Design and install the track
		<u>Track on Column</u> Supply and installation of column including welding of the top plate of column to match with the base plate of track assembly and ensure the same to correct line and level.	Design and install track on column.
		<u>Track embedded in concrete</u> Lay 1 st pour concrete in the bed. Laying of 3 rd pour concrete (RCC) up to top of the rail (except flange way)	Design and install track including laying of second pour concrete (RCC) up to the bottom of the bearing plates duly assembling the track in position.
		<u>Track on plinth in washing line</u> Prepare 1 st pour in the bed. Provide shear connectors.	Install the angle (for creating the flange way) Design and install track including the plinth.
5	Temporary water supplies for construction of track	Shall coordinate	Shall make his own arrangements without affecting the other Contractors' works.
6	Access and storage	Shall provide suitable roads for gaining access to various location in depot for executing track work and also for storing the required track materials	Transportation of track material to site in specified space and period so that the construction activities systems / infrastructure is not hampered after access period.

Item No.	Item Description	Depot Civil Contractor	Track work Contractor
7	Provision of transition slabs between ballast less track on ramp and ballasted track at- grade in depots	Shall construct and provide the slabs	Shall coordinate to ensure construction as per agreed designs
8	Paved Areas	Depot Contractor (Civil) to provide paving at all locations except in track area up to sleeper length	Paving to be provided by track work Contractor (with check rail) in track area
	T&C Stage		
9	Nil		
	Maintenance Stage		
10	Nil		

4.1.15 INTERFACES WITH M&P CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Item Description	Depot Civil Contractor	M&P Contractor
	Design Stage		
1	Various M&Ps requirement of space and power	Shall consider the space, foundation, power, water and any other utility requirements furnished by M&P Contractors in the design of depot facilities	Shall furnish GADs, power requirement, water/piping requirements and other requisite details to Depot Contractor
	C&I Stage		
2	Automatic Train Wash Plant	<ul style="list-style-type: none"> • Demarcation of ATWP area according to Depot layout. • Construct the foundation requirement to install ATWP as required • Control Room for operating station of ATWP • Cable Trench for laying of Cables& wires of the plant. • Inlet Water Reserve to be provided & suitable piping to the Inlet point / Tank of the ATWP as per the suppliers GAD • Collection point for waste water • Waste water drain / piping to transfer the waste water to the Depot ETP. 	<ul style="list-style-type: none"> • Provide plant GAD and other details for construction.

Item No.	Item Description	Depot Civil Contractor	M&P Contractor
		<ul style="list-style-type: none"> Power connection within 15m of the plant panel, as per the electrical load ratings provided by the supplier 	
3	CNC Under floor Wheel Lathe with Synchronized Shunting System	<ul style="list-style-type: none"> Suitable shed as per depot layout with sufficient illumination and ventilation consisting day and night working Construct the pit with foundation as required EOT crane of 5-ton capacity or as per Technical Specifications with travel along the shed bay length Plain concrete workshop floor outside the pit area with colour as per Employer's choice Electrical supply point within 15m from the pit (120 KVA) with common earthing connection point Both side entry openings to be sufficient for entering 25-ton mobile crane Floor to flush with rail to the level of top of the rail Drain point at two sides of the shed and related drainage system to be provided 	<ul style="list-style-type: none"> Provide plant GAD and other details as required by Depot Contractor
4	Under floor train lifting system for 6-car unit	<ul style="list-style-type: none"> Space should be left for civil work of UFLS by M&P Contractor Construct the pit with foundation as required Plain concrete workshop floor outside the Pit area with colour as per Employer's choice Electrical supply point within 15m from the pit (75 KVA) with common earthing connection point 	<ul style="list-style-type: none"> Provide plant GAD and other details as required by Depot Contractor
5	Mobile lifting jacks for 6-car unit	<ul style="list-style-type: none"> Plain concrete workshop floor outside the Pit area with colour as per Employer's choice 	<ul style="list-style-type: none"> Provide GAD of the Mobile Lifting Jack system

Item No.	Item Description	Depot Civil Contractor	M&P Contractor
		<ul style="list-style-type: none"> Electrical cabling conduits as per GAD along with pockets for connection points Electrical supply point within 15m from the pit (40 KVA) with common earthing connection point 	
6	Bogie Testing Machine	<ul style="list-style-type: none"> Plain concrete workshop floor outside the Pit area with colour as per Employer's choice Construct the pit with foundation as required Electrical supply point within 15m from the pit (30 KVA) with common earthing connection point 	<ul style="list-style-type: none"> Provide GAD of the Bogie testing machine
7	Bogie turntables	<ul style="list-style-type: none"> Plain concrete workshop floor outside the Pit area with colour as per Employer's choice Construct the pit with foundation as required 	<ul style="list-style-type: none"> Provide GAD of the Bogie turntables
8	Multi-functional work station	<ul style="list-style-type: none"> Drawing of the Inspection Bay as required Design and provide the roof structure as per load details of multi-functional station Plain concrete workshop floor outside the Pit area with colour as per Employer's choice Electrical point within 15m from the control panel 	<ul style="list-style-type: none"> Provide GAD and load requirements of the shed roof structure
9	Various machines in wheel shop	<ul style="list-style-type: none"> Space should be left for civil work of various machines by M&P Contractor Plain concrete workshop floor outside the Pit area with colour as per Employer's choice Electrical supply point within 15m from the panel with common earthing connection point 	<ul style="list-style-type: none"> Provide GAD and other details of machines as required by Depot Contractor Construct the Foundation with pit finishing as required
	T&C Stage		
10	Power supply to M&Ps	Shall lead for testing of power supply to various M&Ps (if under Civil scope)	Shall coordinate
	Maintenance Stage		
11	Nil		

4.1.16 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 2.1.14 above](#) shall apply as relevant to the context

CHAPTER 5

5.0 ELEVATED E&M (VIADUCT & STATION) CONTRACTORS' INTERFACES

5.1.1 INTERFACES WITH ELEVATED CIVIL (VIADUCT & STATIONS) CONTRACTOR

Refer to [Para 2.1.3 above](#)

5.1.2 INTERFACE WITH ELEVATED STATIONS FINISHING CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Elevated E&M Contractor	Elevated Station Finishing Contractor
	Design Stage		
1	Equipment rooms, sumps, conduit and ducts	<ul style="list-style-type: none"> • Shall prepare the CSD. • Shall provide details of room requirement along with load details. • Shall prepare equipment, cable, raceways, trunking, seepage, sewage, hydrant, domestic water pipeline etc. route drawing in stations. • Shall provide designing of lighting layout based on input given by Civil Contractor. • Shall provide the input for earth pit layouts, cable pull route, lighting etc., at road level of station building. • Shall furnish the floor/room finishing requirements i.e., hardonite, epoxy floor, louvers etc., • Shall furnish the cut-out/hatch/opening requirement for cable, raceways, trunking, seepage, sewage, hydrant, domestic water pipeline etc., route drawing in stations. • Shall provide input for SEM drawings • Shall review CSD and SEM as and when required. 	<ul style="list-style-type: none"> • Shall provide final station layout drawings for preparation of CSD. • Shall incorporate the details of room requirements along with civil load details provided by E&M Contractor. • Shall incorporate input from the E&M Contractor in the production of Structural E&M drawings (SEM) that will show all the necessary openings, cutouts, hatch, core cutting plinths, foundations etc. • Shall provide details of the false ceiling drawings for designing of lighting layout to E&M Contractor. • Shall review the CSD and SEM as and when required.
	C&I Stage		

Item No.	Subject	Elevated E&M Contractor	Elevated Station Finishing Contractor
2	Equipment rooms, sumps, conduit and ducts	<ul style="list-style-type: none"> Shall install E&M equipment as required in the E&M scope of works at location provided by the station Contractor. Shall provide raceways, trunking for the E&M works and other system Contractor for all routes defined in the CSDs. Shall close all floor and wall openings provided by Civil Contractor with fire rated material after installation of all E&M services. Installation of seepage, sewage pumps along with embedded discharge pipe up to discharge level outlet. Shall install domestic pumps and provide inlet up to OHT. 	<ul style="list-style-type: none"> Complete equipment rooms such as ancillary building, sumps and other spaces for the installation of the E&M equipment such as pumps, DGs, control panels etc., Provide wall openings, construction of plinths/foundations, sleeves for use of E&M Contractor. Shall close all wall openings in which E&M has provided cableways for other designated Contractors after installation of services by other designated Contractor. Shall provide suitable road access for loading/unloading of the equipment. Installation and commissioning of toilets along with associated fittings in consultation with E&M. Shall coordinate with E&M for false ceiling works, lighting concealed conduiting, urinal sensors, junction boxes related to power sockets and finishing works.
3	Temporary power for installation, testing and commissioning.	<ul style="list-style-type: none"> Shall co-ordinate with Civil Contractor for provision of suitable sockets for temporary power. Shall provide required cables and distribution boards. Shall pay to Civil Finishing Contractor for the power consumption. 	<ul style="list-style-type: none"> Shall provide temporary power as per requirement Shall provide suitable meters for calculating the consumption
	T&C Stage		
4	Nil		
	O&M Stage		
5	Nil		

5.1.3 INTERFACE WITH SIGNALING & TRAIN CONTROL (S&TC) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Elevated E&M Contractor	S&TC Contractor
	Design Stage		
1	Services for signaling Equipment Room, UPS, Signaling Maintenance Room and Station Control Rooms	<ul style="list-style-type: none"> Design room lighting, HVAC, FDA etc., requirements and routing of Cable ducts / cable trays. Shall incorporate the cable containment requirements for ensuring connectivity from Emergency stop plunger up to operational room and station common areas. Review design with the S&TC Contractor. 	<ul style="list-style-type: none"> Suitably interface for marking cable trays by furnishing the size, bending radius, voltage level etc., on the station drawings in close coordination with the DDC/E&M Contractor up to operational rooms and station common area. Shall furnish the equipment/furniture layout. Review design with the DDC/E&M Contractor. Furnish AC load requirements to DDC/E&M Contractor and coordinate with them to ensure AC provision accordingly. Coordinate closely with DDC/E&M Contractor to ensure the requirements at site are met.
2	Cabling infrastructure for Signalling at stations	<ul style="list-style-type: none"> Shall prepare CSD drawings incorporating routing of Cable ducts / hangers / trays for signaling cables throughout the station without clash. Fiber optic cables throughout the station shall have route diversity Design details to be worked out in interface with signaling design requirements. 	<ul style="list-style-type: none"> Suitably interface for marking cable trays by furnishing the size, bending radius, voltage level etc., on the station drawings in close Coordination with the DDC/E&M Contractor. Shall interface and review Design/CSD with the DDC/E&M Contractor. Furnish and review requirements of EMC for cabling. Review and confirm design with the DDC/E&M Contractor and closely coordinate with E&M Contractor to ensure that the requirements at site are met.
3	Station control room	<ul style="list-style-type: none"> Shall design the services like lighting, HVAC, Raw Power requirements. Shall furnish details of equipment's to be placed within SCR like FACP, BMS Etc. 	<ul style="list-style-type: none"> Shall design equipment/furniture layout of the room to DDC/E&M Contractor for appropriate design of lighting, AC, ventilations etc.
4	Provision of Earthing at stations in equipment rooms	Design of main and clean earth provisions including space for earth pits	<ul style="list-style-type: none"> Shall furnish the earthing requirements as per standards. Review design of earthing requirements for Signalling and Train control application

Item No.	Subject	Elevated E&M Contractor	S&TC Contractor
5	Power for signalling UPS	Shall provide two feeders with required switchgears for signalling system UPS from emergency power panel.	Shall furnish load requirements to DDC / E&M Contractor to incorporate in design.
Const./Install. Stage			
6	Services for signaling Equipment Room, UPS, Signaling Maintenance Room and Station Control Rooms	<ul style="list-style-type: none"> Shall supply and install all general lighting, FDA, HVAC, ventilation and power sockets in accordance with equipment/ furniture layout. Shall supply and install isolators and cables up to isolator at UPS Room and extend permanent power supply from ESR MDB. 	Construct all cable trays within the SER, SCR & SMR rooms required for signaling and Train Control System
7	Cabling infrastructure for Signalling at stations	Shall supply and install cable trays/risers and the required containments and support infrastructure up to the signaling rooms in the station area.	<ul style="list-style-type: none"> Install cables for all S&TC systems. Install cable trays / hangers for routing signalling cables inside signal equipment room and signal maintenance room. Seal the gaps after cable installation work with fire resistant material.
8	Station control room	Provide details of UPS supply requirement to the Signalling Contractor for BMS, Lift and Escalator workstations provided in Station Control Room. Provision of power sockets	<ul style="list-style-type: none"> Provide furniture for work stations of all Systems (Signalling, Telecom, AFC, BMS, IT, Lifts, Escalators & FACP) provide UPS supply for workstations for all systems including suitable protection arrangement in UPS room and install signalling equipment within Station Control Room. Cable tray provision of Signalling equipment.
9	Provision of Earthing at stations in equipment rooms	<ul style="list-style-type: none"> Shall supply and construct earth pits, draw connection from pit to MET Inside UPS (S&T) room, Signalling Equipment Room (SER), SMR, SCR and TER Shall supply and install tray support for routing of earthing cable / flats from earth pit to UPS S&T Room. Joint testing to be carried out at earth pits terminals and loop continuity test to be carried out up to MET/CET. 	Shall witness the joint testing
10	Power for signalling UPS	Cable laying and termination of LV cables from emergency power panel up to isolator of signalling UPS.	Cable laying and termination from isolator to UPS.

Item No.	Subject	Elevated E&M Contractor	S&TC Contractor
11	Cable support infrastructure along the viaduct and Stations	Supply and install cable troughs with covers along viaduct and stations on both UP and DOWN tracks as required	<ul style="list-style-type: none"> Supply and install the required mounting/support structure for ESP at platforms. Provide equipment foundations/ pedestals at equipment rooms. Install all Signalling and Train Control equipment, cables etc. Seal the entry/exit openings after cable installation work with fire resistant materials/cable grommet-
	T&C Stage		
12	Power for signalling UPS	Perform testing and commissioning	Associate during T&C to ensure power requirement for S&TC is met
	Maintenance Stage		
13	Nil		

5.1.4 INTERFACE WITH TELECOMMUNICATION (TEL) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	Elevated E&M Contractor	Telecom Contractor
	Design Stage		
1	Services for Telecom Equipment Room (TER), Police Supervisory Booth (PSB), CDMA/TOR room, Security room and Station Control Rooms	<ul style="list-style-type: none"> Design room lighting, HVAC, FDA etc., requirements and routing of Cable ducts / cable trays up to operational rooms and station common areas. Shall incorporate the cable tray/raceway requirements for ensuring connectivity for communication systems in station common areas. Review design with the Telecom Contractor 	<ul style="list-style-type: none"> Suitably interface for marking cable trays by furnishing the size, bending radius, voltage level etc., on the station drawings in close coordination with the DDC/E&M Contractor. Shall furnish the equipment/furniture layout. Review design with the DDC/E&M Contractor. Furnish AC load requirements to DDC/E&M Contractor and coordinate to ensure AC provision accordingly. Coordinate closely with DDC/E&M Contractor to ensure the requirements at site are met
2	Cabling infrastructure for Communication systems at stations	<ul style="list-style-type: none"> Shall prepare CSD drawings incorporating routing of Cable ducts / hangers / trays for communication systems cables throughout the station without clash. Fiber optic cables, Power cables, data cables throughout the station shall have route diversity 	<ul style="list-style-type: none"> Suitably interface for marking cable trays by furnishing the size, bending radius, voltage level etc., on the station drawings in close coordination with the DDC/E&M Contractor. Shall interface and review design/CSD with the DDC/E&M Contractor.

SN	Subject	Elevated E&M Contractor	Telecom Contractor
		<ul style="list-style-type: none"> Design details to be worked out in interface with communication design requirements 	<ul style="list-style-type: none"> Furnish and review requirements of EMC for cabling. Review and confirm design with the DDC/E&M Contractor and closely coordinate with E&M Contractor to ensure that the requirements at site are met
3	Clocks, Public Address System, CCTV cameras & monitors (at selected locations), Passenger Information Display Boards, telephones and Radio access units and other associated HMIs at stations	<ul style="list-style-type: none"> Incorporate locations of CCTV cameras (at specified locations) clocks, telephones, Public address loudspeakers, Passenger Information Display Boards. Design details to be worked out in interface with Telecom Contractor's design requirements 	<ul style="list-style-type: none"> Furnish quantities, position and sizes of space cut-outs to the ceiling/ wall finishes for mounting clocks, telephones, Public address loudspeakers, ambient noise sensors, Passenger Information Display Boards, CCTV cameras / monitors. Confirm standard of acoustic treatment of areas of coverage by PAS throughout the station Review design with the design Contractor and co-ordinate with construction Contractor
4	Train radio antenna system	<ul style="list-style-type: none"> Design details of Cable trays/Raceways from TER to foundation of antenna mounting Tower to be worked out in interface with Telecom design requirements. 	<ul style="list-style-type: none"> Furnish details of Antenna mounting Tower Structure for Train Radio Base Station (s). Furnish tray requirement with necessary bending radius
5	Provision of Earthing at station in Communication equipment rooms, Station Control room, Ticket office, Telecom operator room, TETRA tower	<ul style="list-style-type: none"> Design details to be worked out in interface with Telecom Contractor 	<ul style="list-style-type: none"> Furnish requirements for clean earth and main earth Review design with the design Contractor and co-ordinate with construction Contractor Design detail to provide earthing arrangement to TETRA Tower and lightning arrester
6	Provision of Building Management System (BMS)	Design details to be worked out in accordance with Telecom equipment location and interface requirements	Shall coordinate
C&I Stage			
7	Services for Telecom Equipment Room (TER), Police Supervisory Booth (PSB) and Station Control Rooms	<ul style="list-style-type: none"> Shall supply and install all general lighting, FDA, HVAC, ventilation and power sockets in accordance with equipment/furniture layout and CSD. Lighting fixtures positioning inside room should be with proper illumination for the equipment inside the rack 	<ul style="list-style-type: none"> Construct all cable trays within the TER, SCR & PB rooms required for Communication systems Install conduits (concealed or exposed based on architectural finishes) from cable tray point including termination boxes at Rooms

SN	Subject	Elevated E&M Contractor	Telecom Contractor
8	Cabling infrastructure for Communication systems at stations	<ul style="list-style-type: none"> Shall supply and install cable trays/raceways and the support infrastructure up to the entry of TER, SCR Rooms, Police Booth, Telecom Operator Room and other rooms 	<ul style="list-style-type: none"> Install conduits (concealed or exposed based on architectural finishes) from cable tray point including termination boxes at all stations/depot's areas/ rooms/ancillary building
9	Clocks, Public Address System, CCTV cameras & monitors (at selected locations), Passenger Information Display Boards, telephones and Radio access units and other associated HMIs at stations	<ul style="list-style-type: none"> Shall supply and install cable trays/raceways in station area, Ancillary building etc. 	<ul style="list-style-type: none"> Install clocks, telephones, Public address loud speakers, ambient noise sensors, all types of CCTV cameras / monitors (as required) and Passenger Information Display Boards throughout the station, including all types of primary and secondary mounting fixtures; Install conduits (concealed or exposed based on architectural finishes), cable manager including termination boxes for all telecom equipment's. Install integrated control panel/ work station for Public Address system and PIDS in SCR and control panel for Public Address system in Platform Supervisor's Booths; Install control panel/ work station and monitors for CCTV (at selected locations) in SCR; Install Radio Access Unit in SCR.
10	Train radio antenna system	<ul style="list-style-type: none"> Shall supply and install cable trays/raceways from TER to Base foundation of TETRA Tower(s) with required bending radius as specified by Telecom Contractor 	<ul style="list-style-type: none"> Install Tower and Radio antennae and feeder cables. Earthing connection to TETRA Tower(s) and lighting arrester
11	Provision of Earthing at station in Communication equipment rooms, Station Control room, Ticket office, Telecom operator room, TETRA tower	<ul style="list-style-type: none"> Provide Earth Pits for MET and clean earth Provide MET (termination Strip) separate for clean earth and main earth in Communication equipment room, Station Control room Ticket office, Telecom operator room as per requirement 	<ul style="list-style-type: none"> Connect up the MET and clean earth inside Communication equipment rooms, Station control room Ticket office, Telecom operator room and TETRA tower as per requirement etc. as per requirement
12	Provision of Building Management System (BMS)	<ul style="list-style-type: none"> Supply, installation, testing and commissioning of BMS, including PLCs with Ethernet interface Mod bus TCP protocol at the station level. Provision for overall integration of BMS at OCC/BCC with a central server, including supply, installation and commissioning of required software/hardware at stations. 	<ul style="list-style-type: none"> Providing necessary Ethernet ports and dedicated bandwidth and QOS on the FOTS/GE backbone to transport all the BMS information between stations and OCC/BCC

SN	Subject	Elevated E&M Contractor	Telecom Contractor
	T&C Stage		
13	Power for signalling UPS	Perform testing and commissioning	Associate during T&C to ensure power requirement for Telecom is met
14	PAS / CCTV	Shall interface with Telecom Contractor for achieving full functionalities	Shall lead the T&C of CCTV/PAS system
15	Cable support infrastructure along the viaduct and Stations	Supply and install cable troughs with covers along viaduct and stations on both UP and DOWN tracks as required	<ul style="list-style-type: none"> • Provide equipment foundations/ pedestals at equipment rooms. • Install all Telecom equipment, cables etc. Seal the entry/exit openings after cable installation work with fire resistant materials/cable grommet / anti rodent materials.
	Maintenance Stage		
16	Nil		

5.1.5 INTERFACES WITH POWER SUPPLY& TRACTION (PST) CONTRACTORS

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Item Description	Elevated E&M Contractor	Power Supply &Traction Contractor
	Design Stage		
1	All interface issues	Shall interface with PST Contractor and factor in the relevant requirements in E&M designs	Shall communicate the following requirements: <ul style="list-style-type: none"> • heat load for electrical equipment inside ASS/TSS • power supply for ACDB in ASS/TSS • lighting requirements in ASS/TSS rooms • power sockets requirements in ASS/TSS • SCADA related interface for MDB/inter-tripping • cable /bus-duct connection from ASS transformer to MDB • relay setting and protection coordination between 33kV system and LV system • transformer door interlock with MDB • cable trays inside the ASS/TSS rooms
2	ASS/TSS room	Shall provide the provisional detail of all LT panel layout of ESR wherever ESR is to be combined with ASS/TSS	Shall develop and incorporate the LT panels layout as provided by E&M Contractor along with ASS/TSS equipment layout wherever ESR is to be combined with ASS/TSS

Item No.	Item Description	Elevated E&M Contractor	Power Supply &Traction Contractor
	C&I Stage		
3	ASS/TSS room	<ul style="list-style-type: none"> Shall provide the actual details of all LT panel layout of ESR wherever ESR is to be combined with ASS/TSS 	<ul style="list-style-type: none"> Shall develop and incorporate the LT panels layout as provided by E&M Contractor along with ASS/TSS equipment layout wherever ESR is to be combined with ASS/TSS
4	Earthing in ASS and TSS	<ul style="list-style-type: none"> Shall measure and share the soil resistivity data for design of earth mat Shall install, testing and commissioning of earth mat according to approved design Shall install earth Bus/METs (main earth terminals connected to the earth mat) inside ASS and TSS to facilitate the connection of equipment in accordance with equipment layout issued by PST Contractor 	<ul style="list-style-type: none"> Shall design the earth mat at ASS-TSS, ASS and share the same with E&M Contractors Shall associate during the installation of earth mat and jointly witness for the combined resistance measurement of the earth mat after installation Shall incorporate the MET requirement into equipment layout in ASS-TSS Shall provide and connect various equipment to earth Bus/METs inside ASS/TSS with GI/Copper strips Shall review the E&M drawing of earthing and bonding arrangement pertaining to traction and convey acceptance/approval Shall provide overall philosophical plan of earthing, bonding and stray current protection management scheme Shall prepare a combined earthing and bonding drawing of complete station including the philosophical plan of earthing, bonding and stray current protection management scheme
5	Lighting and ventilation in ASS/TSS	<ul style="list-style-type: none"> Shall provide for special requirements or preferred locations of lights, fans, exhaust fans and other services. Shall design the lighting system inside the ASS/TSS based on the equipment layout plan for Normal/DG/UPS supply. Lighting from UPS backed source to be provided to illuminate safety equipment panel gas flooding system including ETS (blue light), traction notices and warning signage. Any other Power sockets from UPS backed source in ASS/TSS shall be provided as per the requirement of the PST Contractor. 	<ul style="list-style-type: none"> Shall interface with Station Contractors for any special requirements or preferred locations of lights, fans, exhaust fans and other services. Shall provide the equipment layout details inside the ASS/TSS for designing of lighting. Traction Contractor shall provide lighting load details from UPS backed sources & the appropriate locations for the same. Shall interface with E&M Contractor for any special requirement or preferred locations of lights, ventilation/ exhaust fans and any other power requirement

Item No.	Item Description	Elevated E&M Contractor	Power Supply & Traction Contractor
6	Installation of Cable Trays in ASS & TSS	<ul style="list-style-type: none"> Shall provide and install all cable trays inside ASS & TSS and also in the shaft for the cables from the RSS (wherever applicable) for traction works as per requirement given by PST Contractor including the earthing arrangements up to MET Shall close the opening with fire stops after installation of the LT cables/cable trays Shall provide cable trays for ETS cables 	<ul style="list-style-type: none"> Shall interface with E&M Contractor for cable trays required for LV and HV cables inside ASS & TSS Shall provide the details of cables such as weight, diameter, no. of cables/runs, voltage level, minimum bending radius required etc. to E&M Contractor. Shall confirm the requirements for passages for cable path/crossing and alignment of cables in ASS/TSS area Shall witness installation of cable trays etc. and coordinate appropriately Shall close the opening with EPDM modules after installation of the HT cables
7	Cable containment	<ul style="list-style-type: none"> Shall design supply & install cable containment with in station area including TSS/ASS, ASS room & along track in station area as per PST Contractor requirements 	<ul style="list-style-type: none"> Shall coordinate with E&M Contractor for cable containment with in station area and TSS/ASS room
8	Installation of Equipment in ASS and TSS	<ul style="list-style-type: none"> Shall provide lighting & power sockets, in ASS/TSS room as per PST Contractor requirement 	<ul style="list-style-type: none"> Shall supply, transport and install ASS & TSS equipment's including transformers, rectifiers, 33 kV switchgear, HSCB etc. as per Specifications. Shall provide Panel flooding system in HT Switchgear panels as per NBC 2016.
9	Earthing, bonding and stray current protection arrangements inside the ASS/TSSS and in Station area	<ul style="list-style-type: none"> Shall install all necessary support arrangement bracket for BEC inside ASS/TSS room Shall install earth bus / METs (main earth terminals, connected to the earth mats) inside ASS and TSS to facilitate the connection of equipment. Shall supply, provide path and cable support for connecting station earth mats to MET at ASS/TSS room. Shall provide and connect the earth mat risers as per the design to MET in liaison with PST Contractor. 	<ul style="list-style-type: none"> Shall provide schematic arrangement of earthing, bonding and stray current protection management in the stations Shall provide schematic of structure earth terminals, stray current collection mesh in track slab at the stations Shall coordinate and install stray current monitoring equipment Shall install BEC conductor in viaduct and station area as required Shall connect MET at ASS/TSS room in station to BEC by suitable cable Shall give the requirements of MET for earth connections in ASS/TSS room.

Item No.	Item Description	Elevated E&M Contractor	Power Supply & Traction Contractor
			<ul style="list-style-type: none"> Shall provide and connect all the HT and DC equipment to MET including embedded earth conductors
10	Supply to ACDB at ASS/TSS	<ul style="list-style-type: none"> Shall supply and install cable and provide emergency supply (DG, UPS) feeder in emergency panel or from other suitable point to ACDB Cable laying from designated LV panel to ACDB at ASS/TSS Providing 230V/415V AC Power supply at LT Panel for ACDB in ASS/TSS including cable tray/support for traction work (from LV panel to ACDB) Shall connect the cable at the LV panel end 	<ul style="list-style-type: none"> Shall coordinate for cable supports from LV panel to ACDB Shall design, procure & install ACDB & DCDB in TSS/ASS Shall supply and install cable from ACDB to DCDB including provision of DCDB
11	SCADA integration of main incomers and coupling breaker of 415V distribution board (for station)	<ul style="list-style-type: none"> Shall provide E&M cable connection from MDB to RTU in the designated terminal board. 	<ul style="list-style-type: none"> Shall provide RTU and designated terminal board for connection of C&M cables from 415V CBs to RTU
12	Connection from transformer to MDB (cables)	<ul style="list-style-type: none"> Shall provide cable paths and shall connect the transformer to the LV Distribution Board by means of suitable cables as per specifications for each connection. Shall design, supply, terminate and install cable connection from Auxiliary transformer secondary to MDB including the necessary supports required for installation Shall design and provide suitable terminals on the MDB side for facilitating cable connection 	<ul style="list-style-type: none"> Shall provide LT terminals for connection of multiple runs of 3.5 core LT cables and openings in enclosure for cable entry so that no modification on or inside the transformer enclosure is required to be done by E&M Contractor. Shall coordinate and provide the suitable terminals at secondary of the Auxiliary Transformer Shall terminate the LT cable on the Transformer secondary
13	Connection from transformer to MDB (bus duct)	<ul style="list-style-type: none"> Shall design and provide suitable terminals on the MDB side for facilitating bus duct connection. Shall provide location coordinates of MDB to PST Contractor for designing / sizing the bus duct. Shall facilitate for termination of bus duct terminals 	<ul style="list-style-type: none"> Shall design supply and install LV bus duct with copper Bus bar from transformer secondary to MDB including the necessary supports required for installation in coordination with E&M based on design of MDB Shall terminate the LT Bus duct on transformer secondary and at MDB
14	Electrical Protection system	<ul style="list-style-type: none"> Shall provide and install CTs in MDB panel as per the requirement given by PST Contractor. Shall coordinate and provide details of protection design used for low voltage system. 	<ul style="list-style-type: none"> Shall design and provide all protective devices for Auxiliary Transformer protection.

Item No.	Item Description	Elevated E&M Contractor	Power Supply & Traction Contractor
		<ul style="list-style-type: none"> Shall coordinate with PST Contractor pertaining CT Control cable wiring and also providing potential free contacts at MDB for power SCADA connection for monitoring the LV breaker status. 	<ul style="list-style-type: none"> Shall coordinate and provide details of CTs to be installed in MDB for various protection e.g. differential, REF protection to E&M Contractor. Shall design a comprehensive protection system in coordination with E&M Contractor.
15	Transformer door interlock	<ul style="list-style-type: none"> Shall install the castle lock as per the requirement of PST Contractor 	<ul style="list-style-type: none"> Shall provide wiring and interlock for transformer enclosure door
16	Inter-tripping between main LV circuit breakers and the 33kV MV circuit breakers of the auxiliary transformers	<ul style="list-style-type: none"> Shall provide necessary terminal details to facilitate inter-tripping Shall coordinate and provide potential free contacts at the respective LV breakers for inter tripping. 	<ul style="list-style-type: none"> Shall provide and connect wire for inter-tripping occurs as per specifications
17	Emergency Trip System (ETS) Installation	<ul style="list-style-type: none"> Shall accommodate the ETS requirements in to the design of cable trays, layouts etc. Shall provide emergency UPS backed 230V LT supply at UPS DB for indication lamp. Shall supply and install cable from uninterrupted 230V LT supply to ETS equipment location indication lamp. Shall provide cable route and install cable support infrastructure (metallic tray, conduit etc.) for LV power cable, PLC cable from SCADA RTU to ETS and telephone cable. All cable support infrastructure shall be provided with necessary earthing arrangements. 	<ul style="list-style-type: none"> Shall provide ETS Load, cable route & cable details. Shall coordinate for locations of ETS at stations platform, ASS/TSS rooms and station control room etc. Shall provide ETS equipment at platforms, SCR and TSS room including mounting arrangement to be provided on the columns/pillar/wall Shall install LV power cable from UPS DB and PLC cable from nearest SCADA RTU to ETS equipment
18	Warning Notices & Indicator boards associated with traction power	<ul style="list-style-type: none"> Shall provide the necessary cable support infrastructure and LT Power Supply for illuminated warning and indicator boards. Provide Socket for Emergency Signage at the station and ASS/TSS. 	<ul style="list-style-type: none"> Shall coordinate and inform locations of third rail warning and indicator boards. Shall furnish the relevant drawings. Shall review the fixing arrangement. Shall supply and install all warning and indicator boards
19	ASS/TSS fire protection	<ul style="list-style-type: none"> Providing 230VAC emergency power supply to control & link to Central Fire alarm system 	<ul style="list-style-type: none"> Provide local gas extinguisher system
20	Cable support, trays etc. from ASS/TSS to TER Room	<ul style="list-style-type: none"> Shall supply, install the cable supports, trays etc. 	<ul style="list-style-type: none"> Shall share cable size, routing details and cable containment required for cables Shall supply, install, test and commission cables

Item No.	Item Description	Elevated E&M Contractor	Power Supply & Traction Contractor
	T&C Stage		
21	33kV/415V auxiliary transformer protection	Shall do the same on secondary side	Shall verify inter-tripping and coordinate relay settings on transformer primary side with those of secondary side provided by E&M
22	SCADA interface	Shall cooperate and associate for achieving the functionality	Shall verify SCADA functionality on MDB side
23	Earthing system	Shall lead the earthing system testing DDC may also involve in testing of Earthing system jointly with E&M Contractor and PST Contractor.	PST Contractor shall co-ordinate with E&M DDC/Contractor to check the resistance value of earth pits, Main-earthing terminal, earth mats.
24	Lighting, ventilation etc.	Shall lead the testing of lighting, HVAC, power sockets etc. in the equipment rooms DDC may also jointly Test the Lighting, HVAC, Power points of RSS, ASS, and TSS in co-ordination with PST Contractor.	PST Contractor shall co-ordinate with E&M DDC/Contractor to check lux level of lighting, HVAC system, and utility power points.
	Maintenance Stage		
25	Nil		

5.1.6 INTERFACE WITH PSD/PSG CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	Elevated E&M Contractor	PSD/PSG Contractor
	Design Stage		
1	Lighting, air-conditioning etc. For PSD / PSG rooms at the station	<ul style="list-style-type: none"> Shall design lighting, HVAC, FDA etc as per PSD/PSG Contractor requirements; Shall incorporate and design cable ducts / cable trays / cable routing. 	<ul style="list-style-type: none"> Mark cable duct / cable tray on the civil / architectural/E&M drawings of the station given by the DDCs /construction Contractor. Shall furnish and Coordinate with E&M Contractor for proper lighting and power sockets/earthing/other safety requirements for PSD/PSG rooms. Review design with the design Contractor. Co-ordinate closely with construction Contractor to ensure the requirements at site are met.
2	Cabling infrastructure for PSG at stations	<ul style="list-style-type: none"> Incorporate routing of Cable ducts/ hangers / trays for PSD/PSG main cables throughout the station. 	<ul style="list-style-type: none"> Mark cable duct/conduits/ tray requirement on the GAD/ architectural/CSD in close coordination with the civil design/E&M and/ or construction Contractor. Furnish and review requirements of EMC for cabling.

SN	Subject	Elevated E&M Contractor	PSD/PSG Contractor
3	Interfaces with fire detection system	<ul style="list-style-type: none"> Design details to be worked out in interface with PSD/PSG Contractor and other system design requirements. Incorporate routing of cable trays 	<ul style="list-style-type: none"> Review and confirm design with the DDCs and closely co-ordinate with construction & E&M Contractor to ensure that the requirements at site are met.
4	Provision of earthing at stations in equipment rooms	Shall plan and take input signal from PSD and integrate with fire detection and firefighting systems Incorporate design of Main Earth including earth pits of Clean and Main Earth.	Shall furnish the interfacing details with fire detection and firefighting systems <ul style="list-style-type: none"> Shall furnish the requirement of earthing system including earth impedance value and earth bars for the PSD/PSG equipment Confirm and coordinate the design with E&M Contractor
5	Power Supply in PSG / PSD room	<ul style="list-style-type: none"> Shall incorporate PSD/PSG Contractor requirements in design. 	Shall furnish the load requirements.
C&I Stage			
6	Lighting, air-conditioning etc. For PSD / PSG rooms at the station	Provide lighting fixtures & ventilation / exhaust fans and power sockets.	<ul style="list-style-type: none"> Install cable trays within the rooms Install all cables etc. Seal the gaps after cable installation work
7	Cabling infrastructure for PSG at stations	<ul style="list-style-type: none"> Provide cable trays/raceways within the station area for PSD/PSG systems up to the equipment rooms. Shall install cable containment/ducts to install control panel, power and control cable according to plan layout. 	<ul style="list-style-type: none"> Install cables for all PSD/PSG systems. Install cable trays /raceways for routing PSD/PSG cables inside signal equipment rooms Seal the gaps after cable installation work with fire resistant material. Shall install control panel, power and control cable according to plan layout. Shall install cable trays, raceways etc. as required for his equipment.
8	LV Power Supply in PSG / PSD room	Shall provide the required Power supply.	Shall co-ordinate and monitor the requirements.
9	Interfaces with fire detection system	Shall install and take signal from PSD and integrate with fire detection and firefighting systems	Shall coordinate
10	PSC-BMS interface	<ul style="list-style-type: none"> Shall coordinate with the PSG Contractor regarding compatibility of protocol and connection Shall provide BMS interface panel in the PSG Equipment room at which PSG Contractor will terminate his connections. All cabling from BMS Interface Panel outwards is responsibility of the BMS Contractor. 	<ul style="list-style-type: none"> The serial link and hardwired link cabling shall be supplied and installed by the PSG Contractor up to and including terminations in the BMS interface panel. Shall coordinate for I/O and point schedule

SN	Subject	Elevated E&M Contractor	PSD/PSG Contractor
11	PSA-BMS interface	Shall provide necessary arrangement at BMS backup panel at PSB for connection from PSG alarm terminal box	Shall provide alarm terminal box at PSB and connection from this box to BMS backup panel
12	Earthing	To provide earthing as per PSD/PSG requirement	To confirm that the earthing provided is as per the requirement and provide earthing for the equipment
T&C Stage			
13	BMS interface	Lead the testing of BMS-PSD interface for full functionality	Associate for BMS-PSD interface for full functionality
14	Power supply arrangement	Lead the testing of power supply arrangement to PSD	Associate for the same
15	Interfaces with fire detection system	Shall lead T&C for ensuring intended functionalities	Shall cooperate and associate
Maintenance Stage			
16	Nil		

5.1.7 INTERFACE WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	Elevated E&M Contractor	AFC Contractor
Design Stage			
1	Ticket Office, Customer Care (EFO) related works	<ul style="list-style-type: none"> Shall incorporate room lighting, Fan/HVAC (In Elevated Stations it's in the scope of E&M and In UG it's in the scope of ECS), FDA etc., requirements and routing of Cable raceways/ cable trays up to operational rooms and station common areas. Shall incorporate the cable tray/raceway requirements for ensuring connectivity for AFC systems in station common areas and Review design with the AFC Contractor. Shall incorporate power sockets, smoke detectors, Lighting arrangements and air-condition / fan provision requirements in EFO and TOM rooms 	<ul style="list-style-type: none"> Shall furnish requirements of raceways, cable routing and cable support provisions on walls and floor, lighting, Air-conditioning / fans and Power sockets etc. Shall ensure the fire safety provisions, proper lighting and illumination in TOM and EFO Review the design from designated Contractor.
2	Passenger Operated Add Value Machine (AVM)/ Ticket Vending Machines (TVM)	Shall design the raceways for TVM/AVM in coordination with AFC Contractor.	Shall furnish the details of raceway for TVM/AVM
3	Automatic Gates related works	Shall design the raceway for AFC gates, TOMs and EFOs in coordination with AFC Contractor	Shall furnish the details of raceway for AFC gates, TOMs and EFOs

SN	Subject	Elevated E&M Contractor	AFC Contractor
4	Fire alarm interface	Shall design fire alarm system to facilitate interface with AFC system, shall verify and accept mutually on a common protocol-for operation in emergency condition	Review design with the E&M Contractor. Shall design the AFC system to interface with fire alarm system. Shall also specify the details like type of signal, communication protocol etc.
5	Fire alarm interface	Shall specify the functional requirements of AFC system	Shall design the software according to functional requirements in emergency condition
C&I Stage			
6	Ticket Office, Customer Care (EFO) related works	<ul style="list-style-type: none"> Shall install room lighting, fan / HVAC (In Elevated Stations it's in the scope of E&M and In UG it's in the scope of ECS), FDA etc., requirements and routing of cable ducts / cable trays up to operational rooms and station common areas. Shall provide the cable tray/raceway requirements for ensuring connectivity for AFC systems in station common areas Shall provide power sockets, smoke detectors, Lighting arrangements and air-condition / fan provision requirements in EFO and TOM room 	<ul style="list-style-type: none"> Shall ensure the execution of required works like, raceways, cable routing and cable support provisions on walls and floor, lighting, Air-conditioning, Power sockets etc. Shall provide UPS power distribution/ LAN cabling from UPS room/ TER/ SCR, Installation of Ticketing Machines, network elements, power distribution, RVCT etc.
7	Passenger Operated Add Value Machine (AVM)/ Ticket Vending Machines (TVM)	Laying of Raceways for power and data lines in the path approved in coordination with Finishing Contractor.	Shall ensure the execution of required works like Raceways and their Path.
8	Automatic Gates related works	Laying of Raceways for power and data lines in the path approved in coordination with Finishing Contractor. Lighting arrangement in station common area near gates as approved.	Shall ensure the execution of required works like Lighting Arrangements, Power and Data lines and Earthing.
9	Fire alarm interface	Provide the interface terminal to AFC Contractor	Shall install and connect the cable from AFC panel to fire alarm control panel
T&C Stage			
10	Nil		
Maintenance stage			
11	Nil		

5.1.8 INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	Elevated E&M Contractor	Elevator (Lift) Contractor
	Design Stage		
1	Elevator	<ul style="list-style-type: none"> Shall incorporate the requirement of Elevator Contractor while designing the Electrical power distribution system, earthing network, Cable Tray connectivity and Fire related safety requirements Consider maintenance access requirements 	<ul style="list-style-type: none"> Provide E&M Contractor with all details of electrical load, shaft lighting and earthing requirements Coordinate fire safety requirement with firefighting systems Furnish location for isolator, monitoring and control panel Consider maintenance access requirements
	C&I Stage		
2	Elevator	<ul style="list-style-type: none"> Provide three phase ATS Box & isolator consisting 4 pole MCCB, ELCB, Phase indication of suitable ratings near Elevator control panel at the location specified by Elevator Contractor DG Power supply shall be provided for each Elevator Provide UPS supply power sockets in SCR for elevator BMS (to be added in S&T scope) Provide cable tray from lift control room to SCR or Electrical Switch Room (ESR) for data cable Provide dedicated MET near Isolator box as specified by Elevator Contractor Provide lift shaft with fire protection measures 	<ul style="list-style-type: none"> Provide data cable for control room from SCR including requirements of BMS Contractor
3	Responsibilities of Contractors for Elevator installation process	Adequate lighting fixtures above the Elevator entry point at all landings for proper illumination	<ul style="list-style-type: none"> Shall confirm. Provide and install LED based Remote Monitoring System in CCC / SCR and Intercom etc. in SCR/MAP/CC. (To be shifted to telecom scope)
	T&C Stage		
4		Fire detectors testing	Shall assist & co-ordinate for performing testing.
	Maintenance Stage		
5	Nil		

5.1.9 INTERFACE WITH ESCALATOR CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	Elevated E&M Contractor	Escalator Contractor
	Design Stage		

SN	Subject	Elevated E&M Contractor	Escalator Contractor
1	Escalator design related	Shall incorporate the requirement of Escalator Contractor while designing the Electrical power distribution system, earthing network, Cable Tray connectivity and Fire related safety requirements	<ul style="list-style-type: none"> Provide E&M Contractor with all details of electrical load and earthing requirements. Co-ordinate for fire safety requirement with firefighting systems. Furnish location for isolator, monitoring and control panel
	C&I Stage		
2	Escalator construction / installation related	<ul style="list-style-type: none"> Provide three phase Isolator box panel consisting 4-Pole MCCB, ELCB, Phase indication near Escalator controller at the location specified by Escalator Contractor Provide fire safety requirement for Escalator as per latest standards. Provide cable tray, Raceways for data cable from Escalator control panel to the station control room (SCR) or Electrical Switch room (ESR). Provide dedicated UPS power socket in the escalator control room, which will be utilized for Escalator lighting system Provide Dedicated MET for each Escalator as it is a requirement from CEIG inspector If separate Escalator Control room is constructed, then provide lighting and power socket in the escalator control room. 	<ul style="list-style-type: none"> Provide Isolating Switch (suitable capacity MCCB and ELCB) before the Escalator controller where the main power supply cable will be terminated. Provide power socket in the escalator Controller / Enclosure. Provide and install Fire detectors in the Escalators Pits and Escalator Control Room / Escalator Controller Cabinet. Provide metallic conduit in the shaft for RMS and Lay communication cable for RMS from Elevators to SCR.
3	Responsibilities of Contractors for Escalator installation process	<ul style="list-style-type: none"> Adequate lighting fixtures above the escalator for proper illumination. UPS supply at Escalator Control Panel as per requirement of Escalator Contractor. 	Shall Co-ordinate
4	Safety requirements: Fire detection and Firefighting systems	<ul style="list-style-type: none"> E&M Contractor to provide connectivity with an isolation valve to connect the Escalator Sprinkler system with station fire hydrant system. E&M Contractor to connect & integrate the smoke detectors provided in the Escalator machine space with station smoke detection & Fire alarm system. 	<ul style="list-style-type: none"> Provide and install Fire detectors and Sprinklers in both Top & Bottom machine space of the Escalators. The Smoke detectors in escalator machine space shall be provided in co-ordination with the E&M Contractor so as to smoke detection & Alarm is integrated with the Station Fire detection system <p>Note: The Smoke detectors provided in the Escalator machine space are designed only to stop the Escalator whenever smoke is detected.</p>
	T&C Stage		
5		Fire detectors testing	Shall assist and co-ordinate

SN	Subject	Elevated E&M Contractor	Escalator Contractor
	Maintenance Stage		
6	Nil		

5.1.10 INTERFACE WITH SIGNAGE CONTRACTOR

Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	Elevated E&M Contractor	Signage Contractor
	Design Stage		
1	Signage Layout drawings with details and locations of illuminated signages	<ul style="list-style-type: none"> • Shall Incorporate the illuminated signage requirements with UPS power supply. • Shall review the drawings as and when required 	<ul style="list-style-type: none"> • Shall provide detailed Signage Layout with details and locations of illuminated signages. • Shall review the drawings as and when required
	C&I Stage		
2	Signage Layout drawings with details and locations of illuminated signages	<ul style="list-style-type: none"> • Shall provide power sockets with UPS power supply as required and as marked. • Shall coordinate with Signage Contractor for performing commissioning activities 	<ul style="list-style-type: none"> • Shall install Illuminated signages • Shall mark the location of Illuminated signages for providing Power sockets. • Shall provide required cables as approved and inter connect power supply from power socket to illuminated signages • Shall perform testing & commissioning activities of signages and attend any rectifications if required

5.1.11 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

General

- 5.1.11.1 BMRCL has plans to implement state-of-the-art IT-based Enterprise Asset Management System (AMS), which shall enable BMRCL to manage and optimize various processes (viz. maintenance management, engineering management, O&M relationship management, supply chain management, reporting etc.)
- 5.1.11.2 The Contractor shall be required to coordinate and interface with AMS Contractor for successful integration of assets / permanent works into the Asset Management System.
- 5.1.11.3 The assets / components / equipment to the required levels of breakdown shall be entered into the AMS.
- 5.1.11.4 The asset data shall be fed into the AMS broadly in three forms:
- (a) Predetermined set of active failures shall be transmitted in real time to OCC via relevant network. AMS shall be able take in this data for processing.

- (b) Data shall be downloaded through GPRS or WLAN at predetermined intervals or locations. AMS shall be capable of interfacing with the concerned database and take in filtered data as per design.
- (c) Other data will be fed manually in the AMS.

5.1.11.5 Preventive and corrective maintenance data generated by the relevant system to raise the work request /work orders, and to update the equipment parameter reading

5.1.11.6 The point of interface to the AMS will be the AMS depot (or other location) rack via Ethernet LAN connectivity.

Responsibilities of Interfacing Parties

5.1.11.7 Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	Elevated E&M Contractor	IT/AMS Contractor
1	Data input format	Shall cooperate and furnish specific requirements of format creation	Shall design the data input format in consultation and duly taking into account the suggestions of Interfacing Contractor
2	Asset data entry to AMS system	Shall be responsible for inputting data related to its assets in the AMS system	Shall guide, support and coordinate
3	Analyzing system Diagnostic Data for Critical Faults and converting them to Work Requests in AMS for immediate attention to Maintenance staff to take appropriate action	Shall cooperate	Shall be responsible
4	Automatic download of the system fault Data to Real Time Database or RTD (Centralized Database). From Here data would be picked by AMS for Analysis. This is the connectivity point between AMS and System.	Shall be responsible	Shall cooperate
5	Filtering of only Required (Criticality 1 and 2) to be pushed to AMS via agreed protocol for data exchange.	Shall be responsible	Shall cooperate
6	Categorizing the Total fault list for system on criticality basis.	Shall be responsible	Shall cooperate
7	Finalizing the Meter/ counters (Operation counts of equipment) to be captured in AMS. This data would be used by AMS to trigger preventive maintenance and condition-based maintenance in AMS	Shall be responsible	Shall cooperate

SN	Subject	Elevated E&M Contractor	IT/AMS Contractor
8	Provide the agreed Meter/ counter details to AMS for processing along with fault data	Shall be responsible	Shall cooperate
9	Finalizing the fault / meter parameters to be exchanged between AMS and system	Shall be responsible	Shall cooperate
10	Creating a final fault List that will be part of AMS diagnosis from the overall fault List	Shall be responsible	Shall cooperate
11	Filtered fault / Meter list approval	Shall be responsible for obtaining approval of BMRCL	Shall cooperate
12	Creating a fault/ Meter database in AMS	Shall associate	Shall be responsible
13	Creating an Interface Design for Data exchange	Shall cooperate	Shall be responsible
14	Interface design document signoff	Shall cooperate	Shall be responsible for obtaining approval of BMRCL
15	Developing interface to push data to AMS	Shall be responsible	Shall cooperate
16	Receiving and processing data to create work requests in AMS	Shall associate	Shall be responsible
17	Preparing test data for test cases	Shall associate	Shall be responsible
18	Preparing test Cases for interface Test	Shall associate	Shall be responsible
19	Testing Interface for required functionality	Shall associate	Shall be responsible
20	Test Report Sign Off	Shall cooperate	Shall be responsible for obtaining approval of BMRCL
21	Deploying the interface on Test/ Production Environments	Shall associate	Shall be responsible
22	Technical Design Document submission and Sign Off	Shall cooperate	Shall be responsible for obtaining approval of BMRCL
23	Cyber Security	The Contractor shall be required to engage with designated Cyber Security Consultant at the early stage of design development. The Contractor shall consider the inputs of Cyber Security Consultant into their design and develop their System Safety & Cyber Security Assurance Plan and submit to BMRCL for approval.	The IT/AMS Contractor shall recommend Cyber Security Guidelines complying the requirements of related standards

CHAPTER 6

6.0 UNDERGROUND E&M CONTRACTORS INTERFACES

6.1.1 INTERFACES WITH UG CIVIL CONTRACTOR

Refer to [Para 3.1.3 above](#)

6.1.2 INTERFACE WITH UG STATIONS FINISHING CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	UG E&M Contractor	UG Station Finishing Contractor
Design Stage			
1	Equipment rooms, sumps, conduit and ducts	<ul style="list-style-type: none"> • Shall prepare equipment, cable, raceways, trunking, seepage, sewage, hydrant, domestic water pipeline (if covered under scope) etc. route drawing in stations. • Shall provide designing of lighting layout based on input given by Civil Contractor. • Shall provide the input for earth pit layouts, cable pull route, lighting etc., at road level of station building. • Shall furnish the floor/room finishing requirements i.e., hardonite, epoxy floor, louvers etc., • Shall furnish the cut-out/hatch/opening requirement for cable, raceways, trunking, seepage, sewage, hydrant and domestic water pipeline etc., route drawing in stations. • Shall provide input for SEM drawings • Shall review CSD and SEM as and when required. 	<ul style="list-style-type: none"> • Shall incorporate input from the E&M Contractor in the production of Structural E&M drawings (SEM) that will show all the necessary openings, cutouts, hatch, core cutting plinths, foundations etc. • Shall provide details of the false ceiling drawings for designing of lighting layout to E&M Contractor. • Shall review the CSD and SEM as and when required.
C&I Stage			
2	Equipment rooms, sumps, conduit and ducts	<ul style="list-style-type: none"> • Shall install E&M equipment as required in the E&M scope of works at location provided by the station Contractor. • Shall provide raceways, trunking for the E&M works and other system Contractor for all routes defined in the CSDs. 	<ul style="list-style-type: none"> • Complete equipment rooms such as ancillary building, sumps and other spaces for the installation of the E&M equipment such as pumps, DGs, control panels etc.,

Item No.	Subject	UG E&M Contractor	UG Station Finishing Contractor
		<ul style="list-style-type: none"> Shall close all floor and wall openings provided by Civil Contractor with fire rated material after installation of all E&M services. Shall close all wall openings in which E&M has provided cableways for other designated Contractors after installation of services by other designated Contractor. Installation of seepage, sewage pumps along with embedded discharge pipe up to discharge level outlet. Shall install domestic pumps and provide inlet up to station. 	<ul style="list-style-type: none"> Provide wall openings, construction of plinths/foundations, sleeves for use of E&M Contractor. Shall provide suitable road access for loading/unloading of the equipment. Installation and commissioning of toilets along with associated fittings in consultation with E&M. Shall coordinate with E&M for false ceiling works, lighting concealed conduiting, urinal sensors, junction boxes related to power sockets and finishing works.
3	Temporary power for installation, testing and commissioning.	<ul style="list-style-type: none"> Shall co-ordinate with Civil Contractor for provision of suitable sockets for temporary power and water supply. Shall provide required cables and distribution boards. Shall provide suitable meters for calculating the consumption Shall pay to Civil Finishing Contractor for the power consumption. <p>Note: If temporary power supply is not available with UG Station Contractor, then the UG E&M Contractor shall arrange his own power supply</p>	Shall provide temporary power & water supply as per requirement
	T&C Stage		
4	Nil		
	O&M Stage		
5	Nil		

6.1.3 INTERFACE WITH SIGNALING & TRAIN CONTROL (S&TC) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	UG E&M Contractor	S&TC Contractor
	Design Stage		

Item No.	Subject	UG E&M Contractor	S&TC Contractor
1	Design stage interfaces for lighting, fire protection, cable routing, cable trays, power sockets, earthing etc.	<ul style="list-style-type: none"> Shall furnish the drawings, designs etc. to S&TC Contractor for marking his requirements. Shall consider the requirements provided by S&TC Contractor in the E&M system designs related to cable trays, lighting, fire protection, LV power supply, sockets, earthing etc. 	<ul style="list-style-type: none"> Shall furnish the following requirements for incorporation in the E&M designs: S&TC cable routing and cable tray requirements for stations and tunnels Equipment room lighting, fire protection etc. Earthing including clean earthing in equipment rooms EMC requirements for S&TC cables and equipment S&TC equipment power requirements and LV power supply to S&TC UPS Shall continuously coordinate with E&M DDC/Contractor for above requirements including marking the requirements on drawings (GAD, CSD) provided by E&M DDC/Contractor.
2	Provision of Earthing at stations in S&TC equipment rooms, Station Control room, UPS/Battery room. Earthing bus along the tunnel/ box wall. (Refer Para 0 above for details)	<ul style="list-style-type: none"> Design details to be worked out in interface with S&TC design requirements; Design of earth and earth bus bar as per relevant standards. 	<ul style="list-style-type: none"> Furnish requirements for clean earth and main earth Review the design from E&M Contractor(s).
Const./Install. Stage			
3	S&TC equipment rooms and Station control rooms	<ul style="list-style-type: none"> Rooms complete with fire protection, lighting fixtures and power sockets. Complete installation of lighting fixtures, detectors and power socket outlets inside the S&TC rooms Complete installation of cable trays/trunking from common areas up to the signaling and UPS rooms. E&M Contractor will provide cable trays only up to the wall leading to the S&TC room. Install clean earthing terminal (MET) at the Signalling Room, S&TC UPS room 	<ul style="list-style-type: none"> Installation of cable on cable trays provided and installed by the E&M Contractor for the exclusive use of the S&TC Contractor S&TC Contractor will supply install cable race ways below raised floor while All cable trays inside the S&TC equipment and UPS rooms Earth connection of S&TC equipment from MET Seal the gaps after cable installation work with fire resistant material.
4	Trackside equipment and Cabling infrastructure for S&TC System	<ul style="list-style-type: none"> Provide cable trays/ supports for main S&TC cables throughout the guide-ways/tunnel walls 	<ul style="list-style-type: none"> Construct all secondary ducts including track crossings (cable hanger to equipment) and

Item No.	Subject	UG E&M Contractor	S&TC Contractor
		<ul style="list-style-type: none"> Provide cable conduits / trays for routing all type of cables for Train Control systems throughout the station and tunnel sections. 	partitioning / providing cable trays channels in main cable ducts as required. <ul style="list-style-type: none"> Install cables for all Signalling systems Furnish locations and install line side equipment's such as signals, LEU units, junction box and their fixing arrangements and provide cabling Coordinate requirements of EMI/EMC separation for cabling.
5	Power supply source (AC 3 phase)	<ul style="list-style-type: none"> E&M to provide AC power from alternative sources and diesel generator in S&TC UPS room with changeover facilities (up to isolator) 	<ul style="list-style-type: none"> Shall coordinate and install S&TC UPS Shall install all wiring / cabling from isolator onwards
6	Provision of Earthing at station in S&TC equipment rooms, Station Control room, UPS/Battery room.	<ul style="list-style-type: none"> E&M Contractor to install cable trays, supports and install earth cable from the main earth terminal to the Clean earth terminals in S&TC equipment rooms 	<ul style="list-style-type: none"> S&TC Contractor to coordinate Earth connection of S&TC equipment from MET
7	Interconnection between Lines at relevant stations – for cable laying.	<ul style="list-style-type: none"> Cable supports / conduits/ trays at stations where lines interconnect. 	<ul style="list-style-type: none"> Install Train Control cables Seal all gaps after cable installation work.
	T&C Stage		
8	Power for signalling UPS	Perform testing and commissioning	Associate during T&C to ensure power requirement for S&TC is met
	Maintenance Stage		
9	Nil		

6.1.4 INTERFACE WITH TELECOMMUNICATION (TEL) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	UG E&M Contractor	Telecom Contractor
	Design Stage		
1	Design stage interfaces for lighting, fire protection, cable routing, cable trays, power sockets, earthing etc.	<ul style="list-style-type: none"> Shall furnish the drawings, designs etc. to TEL Contractor for marking his requirements. Shall consider the requirements provided by Telecom Contractor in the E&M system designs 	<ul style="list-style-type: none"> Shall furnish the following requirements for incorporation in the E&M designs: Telecom cable routing and cable tray requirements for stations and tunnels Equipment room lighting, fire protection etc.

SN	Subject	UG E&M Contractor	Telecom Contractor
		related to cable routing, lighting, fire protection, LV power supply, sockets, earthing etc.	<ul style="list-style-type: none"> • Earthing including clean earthing in equipment rooms • EMC requirements for Telecom cables and equipment • Telecom equipment power requirements • Shall continuously coordinate with E&M DDC/Contractor for above requirements including marking the requirements on drawings (GAD,) provided by E&M DDC/Contractor.
2	PAS interface with Fire System	Shall design interfacing of Fire System with PA System	<ul style="list-style-type: none"> • Shall verify and validate interface of PAS with Fire System
3	Provision of Ethernet Channel for E&M equipment	Shall furnish the requirements	<ul style="list-style-type: none"> • Shall consider the requirements in the design of network
4	UG E&M SCADA and T-SCADA Interface	<ul style="list-style-type: none"> • UG E&M Contractor shall define the control / monitoring requirements and parameter measurement requirements (zone/ group). UG E&M Contractor shall install the local control panel (LCP) and wire it to control all controlled devices. UG Station Contractor shall provide the interface devices with M&E SCADA. • Shall design the interface device for each monitored / controlled equipment, Local control panel (where applicable) for the station E&M equipment, LV power distribution, UPS, DG, lighting systems and building management systems installed under the UG E&M Contractor. • Shall advise the locations and connectivity requirements of interface devices associated with E&M equipment to be monitored / controlled by non-traction SCADA 	<ul style="list-style-type: none"> • Shall design the T-SCADA system to suit the requirements of controlled / monitored Non-traction SCADA systems to be installed by UG Station Contractor. • Shall validate the interface design. Design the connectivity requirements from the interface devices up to the CER and to the SCR / OCC. • Shall design the HMI of T-SCADA at the SCR and OCC to meet the control and monitoring requirements of equipment installed by UG Station Contractor
C&I Stage			
5	Telecom equipment rooms and Station control rooms	<ul style="list-style-type: none"> • Rooms complete with fire protection, gas flooding system (if foreseen), lighting fixtures, earthing and power sockets. • Complete installation of lighting fixtures, detectors and power socket outlets inside the telecom equipment rooms • Complete installation of cable trays/trunking from common areas up to the telecom equipment 	<ul style="list-style-type: none"> • Installation of cable on cable trays provided and installed by the E&M Contractor for the use of the Telecom Contractor • Telecom Contractor will supply install cable race ways below raised floor while • All cable trays inside the telecom equipment rooms • Earth connection of telecom equipment from MET

SN	Subject	UG E&M Contractor	Telecom Contractor
		rooms. E&M Contractor will provide cable trays only up to the wall leading to the telecom equipment room. <ul style="list-style-type: none"> Install clean earthing terminal (MET) at the telecom equipment rooms 	<ul style="list-style-type: none"> Seal the gaps after cable installation work with fire resistant material.
6	Cabling support infrastructure for Telecom System	<ul style="list-style-type: none"> Provide cable trays/ supports for main Telecom cables throughout the guide-ways/tunnel walls Provide conduits/ trays for routing all type of cables for telecom systems throughout the station and tunnel sections. 	<ul style="list-style-type: none"> Construct all secondary ducts including track crossings (cable hanger to equipment) and partitioning / providing cable trays channels in main cable ducts as required. Install cables for all telecom systems Furnish locations and install line side equipment's, junction box and their fixing arrangements and provide cabling Coordinate requirements of EMI/EMC separation for cabling.
7	Power supply source (AC single phase / 3 phase)	E&M to provide AC power from alternative sources and diesel generator in S&TC UPS room with changeover facilities up to isolator.	Shall coordinate and install S&TC UPS
8	Provision of Earthing at station in Telecom equipment rooms, Station Control room, UPS / Battery room.	<ul style="list-style-type: none"> E&M Contractor to install cable trays, supports and install earth cable from the main earth terminal to the Clean earth terminals in telecom equipment rooms 	<ul style="list-style-type: none"> Telecom Contractor to coordinate Earth connection of telecom equipment from MET
9	Clocks, PA System, CCTV cameras & monitors (at selected locations), PIDS Boards, Telephones and Radio access units and other associated HMIs at stations	E&M Contractor to provide Power socket for CCTV, PIDS, monitors & Emergency signage, at locations required by the Telecom Contractor within the station. Note1: Power to Emergency Signage's to be provided by E&M Contractor from Station UPS. Note2: CCTV power to be provided by E&M for Normal & essential feed.	Telecom Contractor to provide location & load details of CCTV camera and monitors, PIDS board, Emergency signage system, direct telephone location radio access units and HMIs at stations
10	Power for telecom UPS	<ul style="list-style-type: none"> Laying of LV cables from emergency power panel up to the telecom UPS room Cable connection at emergency panel end 	<ul style="list-style-type: none"> Coordinating for cable sizing and routing Cable connection at UPS end
11	Provision of Ethernet Channel for E&M equipment	E&M Contractor shall be responsible for installation of monitoring and control equipment and to lay data cable from Telecom interface point in TER to E&M Control and Monitoring equipment.	Telecom Contractor shall provide Ethernet Channel in 1+1 redundancy at Interface point inside Telecom Rack at TER of Stations

SN	Subject	UG E&M Contractor	Telecom Contractor
12	UG E&M SCADA and T-SCADA Interface	Shall install E&M SCADA and interface with Telecom Contractor	Shall install T-SCADA and interface with UG E&M Contractor
	T&C Stage		
13	Power for Telecom UPS	Perform testing and commissioning	Associate during T&C to ensure power requirement for Telecom is met
14	UG E&M SCADA and T-SCADA Interface	Shall interface with Telecom Contractor for achieving full functionalities	Shall interface with UG Contractor for achieving full functionalities
	Maintenance Stage		
15	Nil		

6.1.5 INTERFACES WITH POWER SUPPLY & TRACTION CONTRACTORS

Provision of [Para 0 above](#) applies as relevant for UG sections

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Item Description	UG E&M Contractors	Power Supply & Traction Contractor
	Design Stage		
1	All interface issues	<ul style="list-style-type: none"> Shall interface with PST Contractor and factor in the relevant requirements in E&M designs Shall provide requisite info as requested Shall provide all electrical load for transformer designing / sizing Shall consolidate the earth mat design by considering the requirement of other works including clean earth. 	Shall communicate the following requirements: <ul style="list-style-type: none"> power supply and connected load for ACDB in ASS/TSS short circuit fault current of ASS secondary for Earth mat sizing lighting requirements in ASS/TSS rooms power sockets requirements in ASS/TSS SCADA related interface for MDB/inter-tripping cable /bus-duct connection from ASS transformer to MDB relay setting and protection coordination between 33kV system and LV system transformer door interlock with MDB request total power load in UG stations and tunnels to design the auxiliary transformer rating lighting, fire suppression etc. Shall perform earth mat design for ASS/TSS equipment's
	C&I Stage		

Item No.	Item Description	UG E&M Contractors	Power Supply & Traction Contractor
2	Lighting in ASS/TSS	<ul style="list-style-type: none"> Shall provide for special requirements or preferred locations of lights and other services. Shall design the lighting system inside the ASS/TSS based on the equipment layout plan for Normal/DG/UPS supply. Lighting from UPS backed source to be provided to illuminate safety equipment including ETS [blue light stations] traction notices and warning signage Power sockets from UPS backed source in ASS/TSS shall be provided as per the requirement of the PST Contractor. 	<ul style="list-style-type: none"> Shall interface with E&M Contractors for any special requirements or preferred locations of lights and other services. Shall provide the equipment layout details inside the ASS/TSS for designing of lighting. Traction Contractor shall provide lighting load details from UPS backed sources & the appropriate locations for the same.
3	Installation of Cable Trays in ASS & TSS	Shall provide and install cable trays inside ASS & TSS as per requirement given by PST Contractor including the earthing arrangements up to MET.	<ul style="list-style-type: none"> Shall interface with E&M contractor for cable trays required for LV and HV cables inside ASS & TSS Shall provide the details of cables such as weight, diameter, no. of cables/runs, voltage level, minimum bending radius required etc. to E&M Contractor Shall confirm the requirements for passages for cable path/crossing and alignment of cables in ASS/TSS area Shall witness installation of cable trays etc. and coordinate appropriately
4	Installation of Equipment in ASS and TSS	<ul style="list-style-type: none"> Shall provide lighting & power sockets, ASS/TSS room Shall provide suitable inert gas fire flooding protection as per NFPA 2001 standard for ASS/TSS room. 	<ul style="list-style-type: none"> Shall supply, transport and install ASS & TSS equipment's including transformers, rectifiers, 33 kV switchgear, HSCB etc. as per Specifications. Shall provide Panel flooding system in HT Switchgear panels.
5	Earthing, bonding and stray current protection arrangements inside the in the Underground Stations	<ul style="list-style-type: none"> Shall install all necessary support arrangement bracket for 200 mm² bare earth cable (TEW) in both tunnels Shall supply, provide path and cable support for connecting station earth mats to MET at ASS/TSS room. Shall connect various utilities at station and inside tunnel to Earth Cable as per schematic Shall provide and connect the earth mat risers as per the design to MET in liaison with PST Contractor. 	<ul style="list-style-type: none"> Shall provide schematic arrangement of earthing, bonding and stray current protection management in the stations Shall provide schematic of structure earth terminals, stray current collection mesh in track slab at the stations Shall coordinate and install stray current monitoring equipment Shall install bare earth cable in both tunnels Shall connect station earth mats to Earth cable by cable

Item No.	Item Description	UG E&M Contractors	Power Supply & Traction Contractor
			<ul style="list-style-type: none"> Shall give the requirements of earth mat connections from earth mat to MET in ASS/TSS room. Shall provide and connect all the HT and DC equipment to MET including embedded earth conductors
6	Supply to ACDB at ASS/TSS	<ul style="list-style-type: none"> Providing 415V AC Power & DG supply to ACDB in ASS/TSS to be terminated at isolator Cable laying from designated LV panel to ACDB at ASS / TSS Installing cable support and cable from LV panel to ACDB in ASS/TSS Shall connect the cable at the LV panel end 	Connected load of the ACDB shall be provided.
7	SCADA integration of main incomers and coupling breaker of 415V distribution board (for station)	Shall provide E&M cable connection from MDB to RTU in the designated terminal board.	Shall provide RTU and designated terminal board for connection of C&M cables from 415V CBs to RTU
8	Connection from transformer to MDB (bus duct)	<ul style="list-style-type: none"> Shall design and provide suitable terminals on the MDB side for facilitating bus duct connection. Shall provide location coordinates of MDB to PST Contractor for designing / sizing the bus duct. 	<ul style="list-style-type: none"> Shall design supply and install LV bus duct with copper Bus bar from transformer secondary to MDB including the necessary supports required for installation in coordination with E&M based on design of MDB
9	Electrical Protection system	<ul style="list-style-type: none"> Shall provide and install CTs in MDB panel as per the requirement given by PST Contractor. Shall coordinate and provide details of protection design used for low voltage system. Shall coordinate with PST Contractor pertaining CT Control cable wiring and also providing potential free contacts at MDB for power SCADA connection for monitoring the LV breaker status. 	<ul style="list-style-type: none"> Shall design and provide all protective devices for Auxiliary Transformer protection. Shall coordinate and provide details of CTs to be installed in MDB for various protection e.g. differential, REF protection to E&M Contractor. Shall design a comprehensive protection system in coordination with E&M Contractor.
10	Transformer door interlock	Shall install interlock supplied by PS Contractor on MDB	Shall provide wiring and interlock for transformer enclosure door
11	Inter-tripping between main LV circuit breakers and the 33kV MV circuit breakers of the	<ul style="list-style-type: none"> Shall provide necessary terminal details to facilitate inter-tripping Shall coordinate and provide potential free contacts at the respective LV breakers for inter tripping. 	Shall provide inter-tripping circuits as per requirements shown in specifications for stations

Item No.	Item Description	UG E&M Contractors	Power Supply & Traction Contractor
	auxiliary transformers		
12	Emergency Trip System (ETS) Installation	<ul style="list-style-type: none"> Shall provide emergency UPS backed 230V LT supply at all ETS equipment location for indication lamp through Fire rated cables. Shall provide cable route and install cable support infrastructure (metallic tray, conduit etc.) for PLC cable from SCADA RTU to ETS and telephone cable. All cable support infrastructure shall be provided with necessary earthing arrangements. 	<ul style="list-style-type: none"> Shall provide ETS Load, cable route & cable details. Shall coordinate for locations of ETS at stations, tunnel, cross passages, station control room etc. Shall provide ETS equipment at stations, cross passages and other appropriate locations. Shall install PLC cable from nearest SCADA RTU to ETS equipment
13	Warning Notices & Indicator boards associated with traction power	<ul style="list-style-type: none"> Shall provide the necessary cable support infrastructure and LT Power Supply for illuminated warning and indicator boards. Provide Socket for Emergency Signage inside the tunnel 	<ul style="list-style-type: none"> Shall coordinate and inform locations of third rail warning and indicator boards. Shall furnish the relevant drawings. Shall review the fixing arrangement. Shall supply and install all warning and indicator boards
14	ASS/TSS Fire Protection	<ul style="list-style-type: none"> Providing 230VAC emergency power supply to control & link to Central Fire alarm system. Room gas flooding system as per requirements to be provided 	Provide local gas extinguisher system
15	Installation of 33 KV, 750 V cables, traction return cables and PLC cable for ETS connection and other control cables, earth strips/ earth cables in station and tunnel area.	<ul style="list-style-type: none"> Shall design, supply and install cable trays (including metallic support, brackets, cable ladder including calculations etc.) as per requirement in stations and tunnels Design, supply, installation of cable trays inside the ASS/TSS by UG (E&M) Contractor All cable supports inside the tunnel and at station area for 33 kV cable, earthing cables, other control cables to be provided by E&M Contractor 	<ul style="list-style-type: none"> Shall supply & install 33 KV, 750 V, return cables and PLC cable for ETS connection other control cables, earth strips/earth cables in station and tunnel area. Shall co-ordinate and give requirements to the UG (E&M) for the cable path, gallery size, route alignment and mounting requirements for 33 KV, 750 V, positive & return cables, LV AC cables, LV control cables, earthing strips/cables and PLC cable for ETS connection in the tunnel. Shall confirm the requirements for passages for cable crossing and alignment of cables in station area. Shall witness installation of cable supports.
T&C Stage			
16	33kV/415V auxiliary transformer protection	Shall do the same on secondary side	Shall verify inter-tripping and coordinate relay settings on transformer primary side with those of secondary side provided by E&M

Item No.	Item Description	UG E&M Contractors	Power Supply &Traction Contractor
17	SCADA interface	Shall cooperate and associate for achieving the functionality	Shall verify SCADA functionality on MDB side
	Maintenance Stage		
18	Nil		

6.1.6 INTERFACE WITH PSD/PSG CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions apply as for elevated stations – refer [Para 5.1.6 above](#)

6.1.7 INTERFACE WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR

Same provisions apply as for elevated stations – refer [Para 5.1.7 above](#)

6.1.8 INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR

Same provisions apply as for elevated stations – refer [Para 5.1.8 above](#)

6.1.9 INTERFACE WITH ESCALATOR CONTRACTOR

Same provisions apply as for elevated stations – refer [Para 5.1.9 above](#)

6.1.10 INTERFACE WITH TVS CONTRACTOR

Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	UG E&M Contractor	TVS Contractor
	Design Stage		
1	Equipment rooms, major TVS equipment electrical load capacities	Shall consider the TVS requirements in the E&M system design as appropriate	Shall furnish the following requirements to E&M Contractor for incorporation in the E&M designs: <ul style="list-style-type: none"> Electrical loading capacities and requirements for the TVS equipment Location of MCC panels Furnish power requirements (Normal & DG) to take three phase and single-phase incoming power

Item No.	Subject	UG E&M Contractor	TVS Contractor
			supply for Tunnel ventilation system equipment with ATS arrangement <ul style="list-style-type: none"> Equipment room lighting, fire protection, earthing requirements
2	LHD Cable	Shall provide the Linear Heat Detection (LHD) cable in tunnel and station track level; interface of LHD with FACP	Shall co-ordinate & consider the I/O points at station level FACP for the Linear Heat Detection (LHD) cable
3	Cable brackets in tunnel	Shall provide the cable brackets in tunnel	Shall give the size of the cables for finalizing the cable brackets.
C&I Stage			
4	Cable support infrastructure	Provide the cable trunking / tray in the tunnels and common station area	Shall coordinate
5	LV power cables and terminations	<ul style="list-style-type: none"> Provide electrical cable provision from ASS to TVS MCCs & track way exhaust MCC (termination into MCC by E&M Contractor) Shall provide power cable from E&M power supply panel to TVS electrical panel 	Shall coordinate
6	Lighting, fire protection etc.	Provide electrical and fire protection requirements to TVS plant rooms in stations	Shall coordinate
7	Earthing	<ul style="list-style-type: none"> Provision of main earth and clean earth terminals in TVS plant room and TVS control rooms Shall provide the earth bus (MET) in the Tunnel Ventilation equipment room 	Shall coordinate
8	Power supply	<ul style="list-style-type: none"> Shall install electrical cable and cable tray from ASS to TVS MCCs & track way exhaust MCC (termination into MCC by E&M Contractor) Shall provide DG backup supply for TVS equipment Shall provide UPS power supply to TVS SCADA. 	Shall coordinate
9	Monitoring system	Provision provided through Interface terminal board/Interface unit / Control module/Monitor module. Shall provide the location of Interface terminal board / Interface unit / control module/Monitor module	Shall provide cabling up to Interface terminal board / interface unit to get control signal from fire alarm main panel to Smoke Control Panel/Motor control center directly or via SCADA for the operation of Track way exhaust system and Tunnel ventilation system during a fire in station track way, tunnel and cross over. Shall

Item No.	Subject	UG E&M Contractor	TVS Contractor
			provide Tunnel Ventilation system functions for fire in station track.
10	LHD cable	Shall provide the Linear Heat Detection cable in tunnel as well as the station track level The LHD cable shall be connected to FACP	Shall co-ordinate and consider the I/O points at station level for LHD cable
	T&C Stage		
11	Power supply	Shall provide permanent/regular power supply to TVS equipment's for testing & commissioning. Shall also provide UPS power supply during testing and commissioning of TVS SCADA.	Shall associate
	O&M Stage		
12	TVS system O&M	Shall cooperate and support the O&M activities of TVS system	Shall lead the O&M activities of TVS system

6.1.11 INTERFACE WITH ECS CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	UG E&M Contractor	ECS Contractor
	Design Stage		
1	Equipment rooms, major ECS equipment electrical load capacities	<ul style="list-style-type: none"> Shall consider the ECS requirements in the E&M system design as appropriate Furnish E&M equipment heat load data for factoring the same in ECS system design 	<ul style="list-style-type: none"> Shall furnish the following requirements to E&M Contractor for incorporation in the E&M designs: Electrical loading capacities and requirements for the ECS equipment Location of MCC panels Furnish power requirements (Normal, DG & UPS) to take three phase and single-phase incoming power supply for ECS equipment Equipment room lighting, fire protection, earthing requirements ECS monitoring system requirements at SCR/OCC (BMS) Shall consider the E&M heat load data in system design

Item No.	Subject	UG E&M Contractor	ECS Contractor
2	Fire alarm zoning	Shall provide station fire zone details along with FACP location and relay modules details connectivity	Shall co-ordinate with UG E&M Contractor on fire zones to prepare the HVAC zones with inputs of fire alarm
3	BMS I/O points	Shall provide E&M equipment I/O point details (soft & hard points) to be provided	Shall co-ordinate with UG E&M Contractor to incorporate in BMS
C&I Stage			
4	Cable support infrastructure	Provides the cable trunking/tray in the common station areas	Shall coordinate
5	LV power cables	<ul style="list-style-type: none"> Provide electrical cable provision from ASS to ECS MCCs Terminate the main power cable from Main Electrical DB to ECS main DB termination into MCC by E&M Contractor 	<ul style="list-style-type: none"> Shall coordinate and provide location of MCC panels Provide all Electrical cables, trays from ECS MCCs to ECS equipment and ECS and BMS local panels
6	BMS	Shall coordinate	All BMS connections in SCR room to E&M equipment as explained in specification
7	Earthing	Provision of main earth and clean earth terminals and terminate into the earthing bars/strip in ECS plant room, ECS control rooms, SCR and all the necessary rooms	Provision of earthing from earthing bars/strips (inclusive) to all ECS and BMS equipment.
8	Power supply	<ul style="list-style-type: none"> Shall Install (Normal & DG) three phase incoming power supply for ECS equipment's with ATS arrangements to main distribution board. Shall provide the DG back up supply for ECS emergency equipment Shall provide the UPS power supply for the BMS equipment's. 	Shall co-ordinate and provide the requirement for the DG back up for the equipment
T&C Stage			
9	Power supply	Shall provide permanent/regular power supply to ECS equipment's for testing & commissioning. Shall also provide UPS power supply during testing and commissioning of ECS SCADA/BMS-	Shall associate
10	BMS	Shall associate for BMS testing & commissioning for all E&M equipment	Shall lead for testing & commissioning of BMS
O&M Stage			
11		Shall support the O&M activities of ECS system	Shall coordinate

6.1.12 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 5.1.11 above](#) shall apply as relevant to the context

CHAPTER 7

7.0 DEPOT E&M CONTRACTORS INTERFACES

7.1.1 INTERFACES WITH DEPOT CIVIL CONTRACTOR

Refer to [Para 4.1.3 above](#)

7.1.2 INTERFACE WITH DEPOT FINISHING CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Depot E&M Contractor	Depot Finishing Contractor
Design Stage			
1	Equipment rooms, sumps, conduit and ducts	<ul style="list-style-type: none"> • Shall prepare equipment, cable, raceways, trunking, seepage, sewage, hydrant, domestic water pipeline etc. route drawing in depot. • Shall provide designing of lighting layout based on input given by Civil Contractor. • Shall provide the input for earth pit layouts, cable pull route, lighting etc., at road level of depot building. • Shall furnish the floor/room finishing requirements i.e., hardonite, epoxy floor, louvers etc., • Shall furnish the cut-out/hatch/opening requirement for cable, raceways, trunking, seepage, sewage, hydrant and domestic water pipeline etc., route drawing in depot. • Shall provide input for SEM drawings • Shall review CSD and SEM as and when required. 	<ul style="list-style-type: none"> • Shall incorporate input from the E&M Contractor in the production of Structural E&M drawings (SEM) that will show all the necessary openings, cutouts, hatch, core cutting plinths, foundations etc. • Shall provide details of the false ceiling drawings for designing of lighting layout to E&M Contractor. • Shall review the CSD and SEM as and when required.
C&I Stage			
2	Equipment rooms, sumps, conduit and ducts	<ul style="list-style-type: none"> • Shall install E&M equipment as required in the E&M scope of works at location provided by the depot Contractor. • Shall provide raceways, trunking for the E&M works and other system Contractor for all routes defined in the CSDs. 	<ul style="list-style-type: none"> • Complete equipment rooms such as ancillary building, sumps and other spaces for the installation of the E&M equipment such as pumps, DGs, control panels etc., • Provide wall openings, construction of plinths/foundations, sleeves for use of E&M Contractor.

Item No.	Subject	Depot E&M Contractor	Depot Finishing Contractor
		<ul style="list-style-type: none"> Shall close all floor and wall openings provided by Civil Contractor with fire rated material after installation of all E&M services. Shall close all wall openings in which E&M has provided cableways for other designated Contractors after installation of services by other designated Contractor. Installation of seepage, sewage pumps along with embedded discharge pipe up to discharge level outlet. Shall install domestic pumps and provide inlet up to OHT. 	<ul style="list-style-type: none"> Shall provide suitable road access for loading/unloading of the equipment. Installation and commissioning of toilets along with associated fittings in consultation with E&M. Shall coordinate with E&M for false ceiling works, lighting concealed conduiting, urinal sensors, junction boxes related to power sockets and finishing works.
3	Temporary power for installation, testing and commissioning.	<ul style="list-style-type: none"> Shall co-ordinate with Civil contractor for provision of suitable sockets for temporary power. Shall provide required cables and distribution boards. Shall pay to Civil Finishing contractor for the power consumption. 	<ul style="list-style-type: none"> Shall provide temporary power as per requirement Shall provide suitable meters for calculating the consumption
	T&C Stage		
4	Nil		
	O&M Stage		
5	Nil		

7.1.3 INTERFACES WITH SIGNALING & TRAIN CONTROL (S&TC) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Depot E&M Contractor	S&TC Contractor
	Design Stage		
1	Services for Signaling Equipment Room, UPS, Signaling Maintenance Room and Depot Control Centre.	Incorporate room requirements including lighting, HVAC, FDA etc., requirements and routing of Cable ducts / cable trays.	<ul style="list-style-type: none"> Suitably interface for marking cable trays by furnishing the size, bending radius, voltage level etc., on the depot drawings in close coordination with the DDC/E&M Contractor. Shall furnish the equipment/furniture layout. Review design with the DDC/E&M Contractor.

Item No.	Subject	Depot E&M Contractor	S&TC Contractor
			<ul style="list-style-type: none"> Furnish AC/Heat load requirements to DDC/E&M Contractor and coordinate with E&M to ensure AC provision accordingly. Coordinate closely with DDC/E&M Contractor to ensure the requirements at site are met.
2	Cabling infrastructure for Signaling at Depot	Shall design and prepare CSD drawings incorporating routing of the cable trenches, with hangers, supports, cable trays, cable troughs, raceways, track crossing, pulpits, raisers for accommodating the Signaling and LT power cables without clash. Design details to be worked out in interface with Signaling design requirements.	<ul style="list-style-type: none"> Shall Review/ mark the requirement of concrete cable ducts for main cables including track / road crossings for Signalling / OFC cables throughout the Depot area. Furnish and confirm sizes and bending radius of trays, hangers, main cable duct and cross track cable ducts for main cables in close coordination. Furnish and review requirements of EMC separation for cabling.
3	Depot Control Centre	Shall design the services like lighting, HVAC, FACP keeping in view of the Signalling requirement.	Shall provide layout of Signalling equipment to E&M DDC for appropriate design of lighting, AC, ventilations etc.
4	Provision of Earthing at Depot in equipment rooms.	Shall Design main and clean earth provisions including space for earth pits.	Design review of earthing requirements for value $<1\Omega$ for Signalling application and $<0.5\Omega$ for Communication applications.
5	Provision of Earthing for Signalling equipment in outdoor depot area.	Provide space as requested by S&TC Contractor	Shall furnish requirements and coordinate
C&I Stage			
6	Services for Signalling Equipment Room, UPS, Signalling Maintenance Room and Depot Control Centre.	<ul style="list-style-type: none"> Shall supply and install all general lighting, FDA, HVAC, ventilation and power sockets in accordance with equipment/furniture layout. Shall supply and install isolators at UPS Room and extend permanent power supply from ESR/MDB. 	<ul style="list-style-type: none"> Coordinate closely with DDC/E&M Contractor to ensure the requirements at site are met. Construct all cable trays within the SER, DCC & SMR rooms required for Signalling and Train Control System.
7	Cabling infrastructure for Signalling at Depot	Shall supply and install cable Hangers / cable trays/risers and the required containments and support infrastructure up to the Signalling rooms in the depot area including cable shafts / risers / hangers within DCC and other buildings within depot for accommodating the Signalling and LT power cables as applicable.	Review the design from detailed design Contractors and closely coordinate with E&M Contractor to ensure that the requirements at site are met.
8	Depot Control Centre	<ul style="list-style-type: none"> Shall provide socket for Raw power supply. 	Provide furniture for work stations of all Systems (Signalling, Telecom, and envisaged services), provide UPS supply for workstations for all systems including

Item No.	Subject	Depot E&M Contractor	S&TC Contractor
			suitable protection arrangement in UPS room and install Signalling equipment within Depot Control Center. Shall supply and install the cable tray for Signalling equipment.
9	Provision of Earthing at Depot in equipment rooms.	<ul style="list-style-type: none"> Shall supply and construct earth pits, draw connection from pit to MET inside UPS (S&T) room, Signalling Equipment Room (SER), SMR, DCC and TER. Shall supply and install tray support for routing of earthing cable / flats from earth pit to UPS and S&T Room. Joint testing to be carried out at earth pits terminals and loop test to be carried out up to MET. 	<ul style="list-style-type: none"> Shall coordinate Shall witness the joint testing.
10	Provision of Earthing for Signalling equipment in outdoor depot area.	Shall supply and construct earth pits	Design earthing topology, setup earths, lay earth cables to meet earthing requirement (Rails will not be used for earthing)
11	Test Track	Shall coordinate as required	The S&TC Contractor shall install all the ATP equipment required for the Test track at the Depot
T&C Stage			
12	Earthing system	Shall lead the earthing system testing DDC may also involve in testing of Earthing system jointly with S&TC Contractor and traction Contractor.	S&TC Contractor shall co-ordinate with E&M DDC/Contractor to check the resistance value of earth pits, Main-earthing terminal, earth mats.
13	Lighting, ventilation etc.	Shall lead the testing of lighting, HVAC, power sockets etc. in the equipment rooms DDC may also jointly Test the Lighting, HVAC, Power points for S&TC system	S&TC Contractor shall co-ordinate with E&M DDC/Contractor to check lux level of lighting, HVAC system, and utility power points.
Maintenance Stage			
14	Nil		

Note: The provisions of [Para 0 above](#) regarding Earthing & Bonding applies for depot also as relevant to the context.

7.1.4 INTERFACES WITH ROLLING STOCK CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item no.	Subject	Depot E&M Contractor	Rolling Stock (RS) Contractor
Design stage			
1	Requirement for commissioning and testing of cars	Based on Engineer's / DDC's broad design and review of RS, DDC shall design the E&M infrastructure facilities for commissioning and testing of cars in nominated Depot(s).	Review the planning by Engineer / DDC and define the minimum E&M facilities required for commissioning and testing the cars in the depot.
2	Metro train Maintenance requirement	Shall design the Depot E&M facilities including all depot buildings, to suit RS requirement	Shall furnish the maintenance schedules and equipment requirement for complete cars, assemblies and subassemblies systems and sub systems
3	Plant and Machinery, test panels, tools and instruments etc.	<ul style="list-style-type: none"> Depot Engineer shall design and develop specifications for supply and commissioning of General-purpose plant and machinery, tools and instruments at Depot. DDC/Depot E&M Contractor shall Incorporate and electrical & mechanical provisions for all Machinery and Plant. 	Provide details of all special tools / test panels suitable for the rolling stock testing, commissioning and maintenance.
C&I Stage			
4	Requirement for commissioning and testing of cars	Shall construct the E&M facilities for commissioning and testing of cars in nominated depot to meet the commissioning schedule of rolling stocks	Coordinate to ensure the minimum facilities required for commissioning and testing the cars in the depot are built timely
5	Metro train Maintenance requirement	Shall construct the E&M facilities needed to meet the maintenance needs as advised by RS Contractor.	Coordinate to ensure the requisite maintenance facilities in the depot are built timely
6	Plant and Machinery, test panels, tools and instruments etc.	Incorporate electrical & mechanical provisions for all Machinery and Plant.	Supply all special tools / test panels suitable for the rolling stock testing, commissioning and maintenance.
T&C Stage			
7	Testing and commissioning	Shall jointly check and confirm the T&C of relevant E&M facilities	Shall co-ordinate and confirm with depot E&M Contractor
8	Integrated testing	Shall coordinate with RS Contractor to complete testing and commissioning work	Require to conduct integrated test with all E&M systems
Maintenance Stage			
9	Nil		

7.1.5 INTERFACES WITH TELECOMMUNICATION (TEL) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	Depot E&M Contractors	Telecom Contractor
	Design Stage		
1	Services for Telecom Equipment Rooms and Depot Control Centre.	Incorporate room requirements including lighting, HVAC, FDA etc., requirements and routing of Cable ducts / cable trays.	<ul style="list-style-type: none"> • Suitably interface for marking cable trays by furnishing the size, bending radius, voltage level etc., on the depot drawings in close coordination with the DDC/E&M Contractor. • Shall furnish the equipment/furniture layout. • Review design with the DDC/E&M Contractor. • Furnish AC load requirements to DDC and coordinate with E&M to ensure AC provision accordingly. • Coordinate closely with DDC/E&M Contractor to ensure the requirements at site are met.
2	Cabling infrastructure for Telecom at Depot	Shall design and prepare CSD drawings incorporating routing of the cable trenches, with hangers, supports, cable trays, cable troughs, raceways, track crossing, pulpits, raisers for accommodating the Telecom and LT power cables without clash. Design details to be worked out in interface with telecom design requirements.	<ul style="list-style-type: none"> • Shall Review/ mark the requirement of concrete cable ducts for main cables including track / road crossings for telecom / OFC cables throughout the Depot area. • Furnish and confirm sizes and bending radius of trays, hangers, main cable duct and cross track cable ducts for main cables in close coordination. • Furnish and review requirements of EMC separation for cabling.
3	Depot Control Centre	Shall design the services like lighting, HVAC, FACP keeping in view of the telecom requirement.	Shall provide layout of Signalling equipment to E&M DDC for appropriate design of lighting, AC, ventilations etc.
4	Provision of Earthing at Depot in equipment rooms.	Shall Design main and clean earth provisions including space for earth pits.	Design review of earthing requirements for value $<1\Omega$ for Signalling application and $<0.5\Omega$ for Communication applications.
5	Provision of Earthing for telecom equipment in outdoor depot area.	Provide space as requested by Telecom Contractor	Shall furnish requirements and coordinate
6	Access Control	Design the doors & door frames for various rooms duly considering the ACS requirements of Telecom Contractor	Advise the details of ACS equipment to be installed on doors and door frames
7	Provision of Ethernet Channel for E&M equipment	Shall furnish the requirements	Shall consider the requirements in the design of network
	C&I Stage		

SN	Subject	Depot E&M Contractors	Telecom Contractor
8	Services for Telecom Equipment Rooms and Depot Control Centre.	Shall supply and install all general lighting, FDA, HVAC, ventilation and power sockets in accordance with equipment/furniture layout.	<ul style="list-style-type: none"> Coordinate closely with DDC/E&M Contractor to ensure the requirements at site are met. Construct all cable trays within the Telecom Equipment rooms required for Telecom System.
9	Cabling infrastructure for telecom at Depot	Shall supply and install cable Hangers / cable trays/risers / cable troughs / supports / raceways / track crossing / pulpits, raisers for accommodating the Telecom and LT power cables and the required containments and support infrastructure up to the telecom rooms in the depot area including cable shafts / risers / hangers within DCC and other buildings within depot for accommodating the telecom and LT power cables as applicable.	Review the design from detailed design Contractors and closely coordinate with E&M Contractor to ensure that the requirements at site are met as per the final CSD.
10	Depot Control Centre	Shall provide socket for Raw power supply.	Shall supply and install the cable tray for telecom equipment.
11	Provision of Earthing at Depot in equipment rooms.	<ul style="list-style-type: none"> Shall supply and construct earth pits, draw connection from pit to bus bar inside telecom equipment rooms. Shall supply and install tray support for routing of earthing cable / flats from earth pit to telecom equipment rooms Joint testing to be carried out at earth pits terminals and loop test to be carried out up to MET. 	<ul style="list-style-type: none"> Shall coordinate Shall witness the joint testing.
12	Provision of Earthing for Signalling equipment in outdoor depot area.	Shall supply and construct earth pits	Design earthing topology, setup earths, lay earth cables to meet earthing requirement (Rails will not be used for earthing)
13	Access Control	Provide doors & door frames for various rooms duly considering the requirements of Telecom Contractor	Install Access Control systems, cables and accessories
14	Provision of Ethernet Channel for E&M equipment	E&M Contractor shall be responsible for installation of monitoring and control equipment and to lay data cable from Telecom interface point in TER to E&M Control and Monitoring equipment.	Telecom Contractor shall provide Ethernet Channel in 1+1 redundancy at Interface point inside Telecom Rack at TER
T&C Stage			
15	E&M SCADA and T-SCADA Interface	Shall interface with Telecom Contractor for achieving full functionalities	Shall interface with UG Contractor for achieving full functionalities
16	PAS / CCTV	Shall interface with Telecom Contractor for achieving full functionalities	Shall lead the T&C of CCV/PAS system

SN	Subject	Depot E&M Contractors	Telecom Contractor
17	Earthing system	Shall lead the earthing system testing DDC may also involve in testing of Earthing system jointly with Telecom Contractor and traction Contractor.	Telecom Contractor shall co-ordinate with E&M DDC/Contractor to check the resistance value of earth pits, Main-earthing terminal, earth mats.
18	Lighting, ventilation etc.	Shall lead the testing of lighting, HVAC, power sockets etc. in the equipment rooms DDC may also jointly Test the Lighting, HVAC, Power points for Telecom system	Telecom Contractor shall co-ordinate with E&M DDC/Contractor to check lux level of lighting, HVAC system, and utility power points.
Maintenance Stage			
19	Nil		

7.1.6 INTERFACES WITH POWER SUPPLY AND TRACTION (PST) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Depot E&M Contractors	Power Supply & Traction Contractor
Design Stage			
1	All interface issues	<ul style="list-style-type: none"> Shall interface with PST Contractor and factor in the relevant requirements in E&M designs Shall prepare detailed drawings for cable routes, trenches, cable trays, cable support infrastructure, earthing arrangement, lighting, ventilation, fire protection etc. 	Shall communicate the following requirements: <ul style="list-style-type: none"> heat load for electrical equipment inside ASS/TSS and OCC (for SCADA) power supply for ACDB in ASS/TSS SCADA related interface for MDB/inter-tripping cable /bus-duct connection from ASS transformer to MDB relay setting and protection coordination between 33kV system and LV system transformer door interlock with MDB earthing requirement for equipment lighting, ventilation and fire protection for equipment rooms power sockets earth mat for ASS/TSS
C&I Stage			
2	ASS/TSS room	Shall provide the detail of all LT panel layout of ESR wherever ESR is to be combined with ASS/TSS	Shall develop and incorporate the LT panels layout as provided by E&M Contractor along with ASS/TSS equipment layout wherever ESR is to be combined with ASS/TSS

Item No.	Subject	Depot E&M Contractors	Power Supply & Traction Contractor
3	Earthing in ASS and TSS	<ul style="list-style-type: none"> • Shall measure and share the soil resistivity data for design of earth mat • Shall install, testing and commissioning of earth mat according to approved design • Shall install earth Bus/METs (main earth terminals connected to the earth mat) inside ASS and TSS to facilitate the connection of equipment in accordance with equipment layout issued by PST Contractor. 	<ul style="list-style-type: none"> • Shall design the earth mat at ASS-TSS, ASS and share the same with E&M Contractors. Shall provide the earthing design calculations and requirements to Depot E&M Contractor. • Shall associate during the installation of earth mat and jointly witness for the combined resistance measurement of the earth mat after installation • Shall incorporate the MET requirement into equipment layout in ASS-TSS • Shall provide and connect various equipment to earth Bus/METs inside ASS/TSS with GI/Copper strips • Shall review the E&M drawing of earthing and bonding arrangement pertaining to traction and convey acceptance/approval • Shall provide overall philosophical plan of earthing, bonding and stray current protection management scheme • Shall review the E & M drawing of earth pits/mats & bonding in depot area with respect to the earthing, bonding and stray current mitigation plan.
4	Lighting and ventilation in ASS/TSS	<ul style="list-style-type: none"> • Shall provide for special requirements or preferred locations of lights, fans, exhaust fans and other services. • Shall design the lighting system inside the ASS/TSS based on the equipment layout plan for Normal/DG/UPS supply. • Lighting from UPS backed source to be provided to illuminate safety equipment panel gas flooding system including ETS (blue light), traction notices and warning signage. • Any other Power sockets from UPS backed source in ASS/TSS shall be provided as per the requirement of the PST Contractor. • Exhaust fans, power sockets for ASS/TSS • Shall provide cable connection from MDB/DB to switching panels of ventilation/ exhaust fans 	<ul style="list-style-type: none"> • Shall interface with Station Contractors for any special requirements or preferred locations of lights, fans, exhaust fans and other services. • Shall provide the equipment layout details inside the ASS/TSS for designing of lighting. • Traction Contractor shall provide lighting load details from UPS backed sources & the appropriate locations for the same. • Shall interface with E&M Contractor for any special requirement or preferred locations of lights, ventilation/ exhaust fans and any other power requirement

Item No.	Subject	Depot E&M Contractors	Power Supply & Traction Contractor
5	Supply to ACDB at ASS/TSS	<ul style="list-style-type: none"> Shall supply and install cable and provide emergency supply (DG, UPS) feeder in emergency panel or from other suitable point to ACDB Providing 230V/415V AC Power supply at LT Panel for ACDB in ASS/TSS including cable tray/support for traction work (from LV panel to ACDB) Shall connect the cable at the LV panel end 	<ul style="list-style-type: none"> Shall design, procure & install ACDB & DCDB in TSS/ASS Shall supply and install cable from ACDB to DCDB including provision of DCDB
6	Installation of Cable Trays in ASS & TSS	<ul style="list-style-type: none"> Shall provide and install all cable trays inside ASS & TSS and also in the shaft for the cables from the RSS (wherever applicable) for traction works as per requirement given by PST Contractor including the earthing arrangements up to MET Shall close the opening with fire stops after installation of the LT cables/cable trays Shall provide cable trays/support infrastructure for ETS cables 	<ul style="list-style-type: none"> Shall interface with E&M Contactor for cable trays required for LV and HV cables inside ASS & TSS Shall provide the details of cables such as weight, diameter, no. of cables/runs, voltage level, minimum bending radius required etc. to E&M Contractor. Shall confirm the requirements for passages for cable path/crossing and alignment of cables in ASS/TSS area Shall witness installation of cable trays etc. and coordinate appropriately Shall close the opening with EPDM modules after installation of the HT cables
7	Fire Detection, Air Conditioning & Lighting	Shall supply and install firefighting system, smoke detectors, air conditioning and lighting arrangements in SCADA server room, UPS & Battery room, Training setup room and theatre room.	<ul style="list-style-type: none"> Shall coordinate with Depot E&M Contractor for the provision of fire detection system, firefighting system, air conditioning and lighting works in SCADA room, UPS & Battery room, Training setup room and theatre room. Shall provide Heat load details to Depot E&M Contractor for all PST related equipment.
8	SCADA integration of main incomers and coupling breaker of 415V distribution board (for station)	Shall provide E&M cable connection from MDB to RTU in the designated terminal board.	Shall provide RTU and designated terminal board for connection of C&M cables from 415V CBs to RTU
9	Connection from transformer to MDB (cables)	<ul style="list-style-type: none"> Shall provide cable paths and shall connect the transformer to the LV Distribution Board by means of suitable cables as per specifications for each connection. 	<ul style="list-style-type: none"> Shall provide LT terminals for connection of multiple runs of 3.5 core LT cables and openings in enclosure for cable entry so that no modification on

Item No.	Subject	Depot E&M Contractors	Power Supply & Traction Contractor
		<ul style="list-style-type: none"> Shall design, supply, terminate and install cable connection from Auxiliary transformer secondary to MDB including the necessary supports required for installation Shall design and provide suitable terminals on the MDB side for facilitating cable connection 	<p>or inside the transformer enclosure is required to be done by E&M Contractor.</p> <ul style="list-style-type: none"> Shall coordinate and provide the suitable terminals at secondary of the Auxiliary Transformer Shall terminate the LT cable on the Transformer secondary
10	Connection from transformer to MDB (bus duct)	<ul style="list-style-type: none"> Shall design and provide suitable terminals on the MDB side for facilitating bus duct connection. Shall provide location coordinates of MDB to PST Contractor for designing / sizing the bus duct. Shall facilitate for termination of bus duct terminals 	<ul style="list-style-type: none"> Shall design supply and install LV bus duct with copper Bus bar from transformer secondary to MDB including the necessary supports required for installation in coordination with E&M based on design of MDB Shall terminate the LT Bus duct on transformer secondary and at MDB
11	33kV/415V auxiliary transformer protection	<ul style="list-style-type: none"> Shall supply and install CTs in MDB panel as per requirement given by PST Contractor Shall coordinate and provide details of protection design used for low voltage system Shall provide potential free contacts for power SCADA connection by PST Contractor for display of LT ACB in MDB to OCC SCADA 	<ul style="list-style-type: none"> Shall coordinate relay settings on transformer primary side with those of secondary side provided by E&M Shall design and provide all protective devices for Auxiliary Transformer protection Shall coordinate and provide detail of CTs to be installed in MDB for various protection e.g., differential, REF protection to Depot E&M Contractor Shall design a comprehensive protection system in coordination with Depot E&M Contractor Display of Status of LT ACB in MDB on OCC SCADA
12	Inter-tripping between main LV circuit breakers and the 33kV MV circuit breakers of the auxiliary transformers	<ul style="list-style-type: none"> Shall provide necessary terminal details to facilitate inter-tripping Shall coordinate and provide potential free contacts at the respective LV breakers for inter tripping. 	Shall provide and connect wire for inter-tripping occurs as per specifications
13	Emergency Trip System (ETS) Installation	<ul style="list-style-type: none"> Shall provide and install supports (metallic tray, conduit etc.) for power and control cables from SCADA RTU to ETS. Shall provide emergency (UPS) 230V LT supply to ETS equipment location indication lamp if required. 	<ul style="list-style-type: none"> Shall coordinate for locations of ETS in depot. Shall install power and control cables from nearest SCADA RTU to ETS equipment

Item No.	Subject	Depot E&M Contractors	Power Supply & Traction Contractor
14	UPS	Shall provide two input supply feeders of 3-phase 415 V AC from different bus bar for SCADA UPS in DB located in UPS room at OCC & BCC	<ul style="list-style-type: none"> Shall supply and install UPS and Batteries in OCC & BCC for SCADA equipment. Shall supply & lay LV power cables (for 2 feeders) from nearest DB in UPS Room at OCC/BCC to UPS for incoming power to UPS.
	T&C Stage		
15	33kV/415V auxiliary transformer protection	Shall do the same on secondary side	Shall verify inter-tripping and coordinate relay settings on transformer primary side with those of secondary side provided by E&M
16	SCADA interface	Shall cooperate and associate for achieving the functionality	Shall verify SCADA functionality on MDB side
17	Earthing system	Shall lead the earthing system testing DDC may also involve in testing of Earthing system jointly with E&M Contractor and traction Contractor.	PST Contractor shall co-ordinate with E&M DDC/Contractor to check the resistance value of earth pits, Main-earthing terminal, earth mats.
18	Lighting, ventilation etc.	<ul style="list-style-type: none"> Shall lead the testing of lighting, HVSC, power sockets etc. in the equipment rooms DDC may also jointly Test the Lighting, HVAC, Power points of RSS, ASS, and TSS in co-ordination with Traction Contractor. 	PST Contractor shall co-ordinate with E&M DDC/Contractor to check lux level of lighting, HVAC system, and utility power points.
	Maintenance Stage		
19	Nil		

7.1.7 INTERFACES WITH RECEIVING SUBSTATION (RSS) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Item Description	Depot E&M Contractor	RSS Contractor
1	LV Power Supply to ACDB at RSS cum depot ASS	Shall supply & install LV MDB at RSS cum depot ASS.	<ul style="list-style-type: none"> Shall supply and install the ACDB. Shall supply and install LV Cable and support from designated LV/MDB panel to ACDB at RSS cum depot ASS.
2	DG Power supply	<ul style="list-style-type: none"> Shall supply, install and commission DG. Shall coordinate Shall coordinate to provide the DG power supply for ACDB. Cable path, trench, duct, bracket etc. for 	<ul style="list-style-type: none"> Shall coordinate Shall coordinate to provide the DG power supply for ACDB. Cable path, trench, duct, bracket etc. for DG supply cable for RSS shall be provided.

Item No.	Item Description	Depot E&M Contractor	RSS Contractor
		DG supply cable for RSS shall be provided if required. • Shall supply and install the LV cables from DG panel to designated ACDB panel.	
3	ASS room	Shall provide Panels, Equipment, DG details in ASS room to incorporate in the layout.	Shall provide required space for the panels, DG & Equipment's as per the design.
4	Cable trench, trays	Shall provide cable schedule, cable trays details in ASS room to design cable trench layout for incoming & outgoing cables.	Shall design cable trench layout for incoming & outgoing cables in the RSS building and from RSS to depot.
5	Earthing	Shall provide details of earthing requirement	Shall design earthing as per the E&M requirement.

7.1.8 INTERFACES WITH PLATFORM SCREEN DOORS / GATES (PSD/PSG) CONTRACTOR

This interface will be applicable in case BMRCL decides to install PSD/PSG in depot (along test track) for system integrated testing and training purposes.

The interface responsibilities of respective Contractors shall be similar to that provided between Station Contractor and PSD/PSG Contractor under [Para 5.1.6 above](#).

Additionally, the Depot Contractor shall provide all civil structure for a mock-up at test track as per the drawings / requirements to be provided by PSD/PSG Contractor. This mock-up facility will be used by BMRCL for training purposes in future.

7.1.9 INTERFACES WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR

Definition and Scope

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to (in case of OCC is provided in Depot):

Item no.	Depot E&M Contractor	AFC Contractor
Design stage		
1	Air conditioning	
	E&M Contractor should cover the air conditioning requirements of AFC Contractor	AFC Contractor will submit the Heat Dissipation list of AFC equipment only in the following rooms: -
	i) OCC Central Computer System	i) OCC Central Computer System
	ii) OCC Work Stations Room	ii) OCC Work Stations Room
	iii) CID/CPD, TOM Room	iii) CID/CPD, TOM Room
	iv) Software Development Centre (SDC)	iv) Software Development Centre (SDC)
	v) AFC Repair Workshop	v) AFC Repair Workshop

Item no.		Depot E&M Contractor	AFC Contractor
2	Ventilation	E&M Contractor should cover, the exhaust fan requirements of AFC Contractor in all AFC rooms	AFC Contractor will define the location of exhaust fan in all AFC rooms
3	Lux level	E&M Contractor should cover the lux level in all AFC rooms according to the requirement	All rooms for the AFC system the lighting lux levels should not be less than minimum level of 350 lux
4	Earthing	<ul style="list-style-type: none"> E&M Contractor should cover the electronic (clean) earthing requirements of AFC Contractor as per the E&M technical specification (0.5 ohms) for all AFC rooms Earth terminal in rooms under the circuit breaker to electric cabinet will be done by AFC Contractor 	AFC Contractor request to connect the Electronic (Clean) earthing by insulated cable connections according to the standard in all AFC rooms and all AFC equipment
5	Power sockets requirements	<ul style="list-style-type: none"> E&M shall assist AFC Contractor 	AFC Contractor will define / provide / cover the power socket, quantity and specific requirements in AFC rooms and for all AFC equipment
6	Smoke detector interface	<ul style="list-style-type: none"> E&M Contractor should cover, the smoke detector in all AFC rooms according to the E&M technical specifications 	All AFC rooms should be covered by smoke detector and should be installed in all AFC rooms
7	UPS supply	<ul style="list-style-type: none"> E&M Contractor should cover in E&M UPS capacity for the AFC Contractor requirements The connection from feeder to electro-mechanical circuit breaker in AFC rooms is the responsibility of E&M Contractor and the connection from the circuit breaker to the AFC electric cabinet, is the responsibility of AFC Contractor 	<ul style="list-style-type: none"> Furnish the equipment load requirements for Software Development Centre (SDC) and AFC Repair Lab
8	Electrical load data	<ul style="list-style-type: none"> E&M Contractor should cover in cabling works the AFC Contractor requirements including cable with MCB installed in TOM at station and in AFC rooms at depot workshop and admin building 	<ul style="list-style-type: none"> AFC Contractor will submit the equipment electrical load data to E&M Contractor for cabling works (3 phase neutral + earth)
9	Cable support infrastructure	<ul style="list-style-type: none"> E&M Contractor should cover in cable tray, junction boxes work, embedded conduits / raceway works the AFC Contractor requirements 	<ul style="list-style-type: none"> AFC Contractor will define quantity, sizing and routing for suspended cable trays, junction boxes and embedded conduits / raceways in civil flooring under the AFC gates, TVMs, Ticket Office Room and Telecom Equipment Room to be provided according to the requirement (In station and in depot workshop and admin building)

Item no.		Depot E&M Contractor	AFC Contractor
10	Fire alarm interface	<ul style="list-style-type: none"> Shall design the fire alarm system (for station) to interface with AFC system. Shall verify and accept mutually the details like type of signal, communication protocol etc. operation in emergency condition Shall specify the functional requirements of AFC system 	<ul style="list-style-type: none"> Shall design the AFC system (for Station) to interface with fire alarm system. Shall also specify the details like type of signal, communication protocol etc. Shall design the software according to functional requirements in emergency condition and degraded modes
C&I Stage			
11	Installation work	E&M Contractor should supply and install AFC requirements mentioned under Design Stage and put to AFC Contractor for witness, approval and acceptance	AFC Contractor shall jointly witness with the E&M Contractor the installation works and takeover the works mentioned under Design Stage for onward AFC Contractor works
T&C stage			
12	T&C works	E&M Contractor should comply and assist to AFC Contractor for the required T&C for works mentioned under Design, Supply and Construction Stage under Contractor B responsibility	AFC Contractor should submit to E&M Contractor the T&C requirements for items mentioned under Design Stage, Supply and Construction stage
Maintenance stage			
13		E&M Contractor should jointly develop with AFC Contractor the E&M Maintenance Plan and Maintenance Manual for efficient future O&M for items mentioned in above three stages	AFC Contractor should jointly develop with E&M Contractor the AFC maintenance plan and maintenance manual for efficient future O&M for items mentioned in above three stages

7.1.10 INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions apply as for elevated stations – refer [Para 5.1.8 above](#)

7.1.11 INTERFACE WITH ESCALATOR CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions apply as for elevated stations – refer [Para 5.1.9 above](#)

7.1.12 INTERFACES WITH M&P CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Item Description	Depot E&M Contractor	M&P Contractor
Design Stage			
1	Various M&Ps requirement of space and power	<ul style="list-style-type: none"> • Shall interface with M&P Contractor and factor in the relevant requirements in E&M designs • Shall prepare detailed drawings for cable routes, trenches, cable support infrastructure, earthing arrangement, lighting, ventilation, fire protection etc. 	<p>Shall furnish the following requirements for Depot E&M Contractor:</p> <ul style="list-style-type: none"> • GADs, layout drawings of M&Ps • Load requirement (normal, DG, UPS supply) • Power sockets • Fire protection • Lighting and ventilation • Earthing • Water / piping • Any special requirement related to E&M.
C&I Stage			
2	Automatic Train Wash Plant	<ul style="list-style-type: none"> • Provide Lighting, ventilation, fire protection system, power sockets, earthing system etc. as required • Provide Cable support infrastructure for laying of Cables & wires of the plant • Provide Inlet Water Reserve to be provided & suitable piping to the Inlet point / Tank of the M&P if covered in the scope of E&M Contractor • Provide Collection point for waste water • Provide Waste water drain / piping to transfer the waste water to the Depot ETP if in the scope of E&M Contractor • Provide power connection within 15m of the plant panel, as per the electrical load ratings by the M&P supplier 	<ul style="list-style-type: none"> • Provide plant GAD and other details as required by Depot E&M Contractor • Install the power and control panels and cables for the M&P
3	CNC Under floor Wheel Lathe with Synchronized Shunting System	<ul style="list-style-type: none"> • Lighting, ventilation, fire protection system, power sockets, earthing system etc. as required (considering day and night working) • Cable support infrastructure for laying of Cables & wires of the plant • Power supply to EOT cranes. 	<ul style="list-style-type: none"> • Provide plant GAD and other details as required by Depot E&M Contractor • Install the power and control panels and cables for the M&P • EOT crane of 5-ton capacity with travel along the shed bay length

Item No.	Item Description	Depot E&M Contractor	M&P Contractor
		<ul style="list-style-type: none"> Provide Electrical supply point within 15m from the pit (120 KVA) with common earthing connection point Drain point at two sides of the shed and related drainage system to be provided if in the scope of E&M 	
4	Under floor train lifting system for 6-car unit	<ul style="list-style-type: none"> Lighting, ventilation, fire protection system, power sockets, earthing system etc. as required (considering day and night working) Cable support infrastructure for laying of Cables & wires of the plant Provide Electrical supply point within 15m from the pit (75 kVA) with common earthing connection point Drain point and related drainage system to be provided if in the scope of E&M 	<ul style="list-style-type: none"> Provide plant GAD and other details as required by Depot E&M Contractor Install the power and control panels and cables for the M&P
5	Mobile lifting jacks for 6-car unit	<ul style="list-style-type: none"> Lighting, ventilation, fire protection system, power sockets, earthing system etc. as required Cable support infrastructure for laying of Cables & wires of the plant Electrical cabling conduits as per GAD along with pockets for connection points Provide Electrical supply point within 15m from the pit (40 kVA) with common earthing connection point 	<ul style="list-style-type: none"> Provide plant GAD and other details as required by Depot E&M Contractor Install the power and control panels and cables for the M&P
6	Bogie Testing Machine	<ul style="list-style-type: none"> Lighting, ventilation, fire protection system, power sockets, earthing system etc. as required (considering day and night working) Cable support infrastructure for laying of Cables & wires of the plant Provide Electrical supply point within 15m from the pit (30 kVA) with common earthing connection point Drain point and related drainage system to be provided if in the scope of E&M 	<ul style="list-style-type: none"> Provide plant GAD and other details as required by Depot E&M Contractor Install the power and control panels and cables for the M&P

Item No.	Item Description	Depot E&M Contractor	M&P Contractor
7	Multi-functional work station	<ul style="list-style-type: none"> Lighting, ventilation, fire protection system, power sockets, earthing system etc. as required (considering day and night working) Cable support infrastructure for laying of Cables & wires of the plant Provide Electrical point within 15m from the control panel 	<ul style="list-style-type: none"> Provide plant GAD and other details as required by Depot E&M Contractor Install the power and control panels and cables for the M&P
8	Various machines in wheel shop	<ul style="list-style-type: none"> Lighting, ventilation, fire protection system, power sockets, earthing system etc. as required (considering day and night working) Cable support infrastructure for laying of Cables & wires of the plant Provide Electrical supply point within 15m from the panel with common earthing connection point 	<ul style="list-style-type: none"> Provide plant GAD and other details as required by Depot E&M Contractor Install the power and control panels and cables for the M&P
T&C Stage			
9	Power supply to M&Ps	Shall lead for testing of power supply to various M&Ps	Shall coordinate
10	Earthing system	Shall lead the earthing system testing DDC may also involve in testing of Earthing system jointly with M&P Contractor and traction Contractor.	M&P Contractor shall co-ordinate with E&M DDC/Contractor to check the resistance value of earth pits, Main-earthing terminal, earth mats.
11	Lighting, ventilation etc.	Shall lead the testing of lighting, ventilation, power sockets etc. in the equipment rooms DDC may also jointly Test the Lighting, HVAC, Power points for M&Ps	M&P Contractor shall co-ordinate with E&M DDC/Contractor to check lux level of lighting, HVAC system, and utility power points.
Maintenance Stage			
12	Nil		

7.1.13 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 5.1.11 above](#) shall apply as relevant to the context

CHAPTER 8

8.0 ELEVATED FINISHINGWORKS CONTRACTORS' INTERFACES

8.1.1 INTERFACE WITH ELEVATED CIVIL WORKS CONTRACTOR

Refer [Para 2.1.4 above](#)

8.1.2 INTERFACE WITH ELEVATED E&M CONTRACTOR

Refer [Para 5.1.2 above](#)

8.1.3 INTERFACE WITH SIGNALING & TRAIN CONTROL (S&TC) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Elevated Finishing Works Contractor	S&TC Contractor
	Design Stage		
1	Layout of rooms at the station Signalling Equipment Room, UPS, Signalling Maintenance Room and Station Control Rooms	Design the finishing works of the equipment rooms in coordination and factoring in the requirements of the S&TC Contractor	<ul style="list-style-type: none"> Suitably interface for marking cable Entry/Exit points and cable trenches in UPS Room on the station drawings in close coordination with the DDC/Construction/Finishing Contractor. Review design with the DDC/Construction/Finishing Contractor. Design furniture layout for all system workstations in SCRs.
2	Cable support infrastructure along the viaduct and Stations	Design the finishing works in coordination and factoring in the requirements of the S&TC Contractor	<ul style="list-style-type: none"> Shall provide the requirement of cable troughs/supports on the GAD/CSD for main cables in close coordination with the civil design and/or construction Contractor.
	C&I Stage		
3	Layout of rooms at the station Signalling Equipment Room, UPS, Signalling MaintenanceRoom and Station Control Rooms	<ul style="list-style-type: none"> Rooms complete with structures, false flooring, false ceiling, cable cut outs & shaft finishes, fire rated doors, cable trenches for S&TC UPS Room, equipment rooms Provide checkered plate for cable trench cover 	<ul style="list-style-type: none"> Suitably interface and coordinate with Finishing Contractors Design and provide furniture layout for all system workstations in SCRs. Provide checkered plate for cable trench cover

Item No.	Subject	Elevated Finishing Works Contractor	S&TC Contractor
4	Cable support infrastructure along the viaduct and Stations	<ul style="list-style-type: none"> Finishing works for Emergency Stop Plunger including embedded pipes for connectivity Cable ducts/cut outs for routing Signalling cables from Viaduct to Station within station area 	<ul style="list-style-type: none"> Shall supply and install the required mounting/support structure for ESP at platforms. Provide equipment foundations/ pedestals at equipment rooms. Install all Signalling and Train Control equipment, cables etc. Seal the entry/exit openings after cable installation work with fire resistant materials/cable grommet.
	T&C Stage		
5	Nil		
	O&M Stage		
6	Nil		

8.1.4 INTERFACE WITH TELECOMMUNICATION (TEL) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Elevated Finishing Works Contractor	Telecom Contractor
	Design Stage		
1	Layout of rooms at the station Telecom Equipment Room	Design the finishing works of the equipment rooms in coordination and factoring in the requirements of the Telecom Contractor	<ul style="list-style-type: none"> Suitably interface for marking cable Entry/Exit points and cable trenches in Telecom Equipment Room on the station drawings in close coordination with the DDC/Construction/Finishing Contractor. Review design with the DDC/Construction/Finishing Contractor.
2	Cable support infrastructure along the viaduct and Stations	Design the finishing works in coordination and factoring in the requirements of the Telecom Contractor	Shall provide the requirement of cable troughs/supports on the GAD/CSD for main cables in close coordination with the civil design and/or construction Contractor.
	C&I Stage		
3	Layout of rooms at the station Telecom Equipment Rooms (TER, CDMA, station security room)	<ul style="list-style-type: none"> Rooms complete with structures, false flooring, false ceiling, cable cut outs & shaft finishes, fire rated doors, cable trenches for Telecom Equipment rooms. Provide checkered plate for cable trench cover 	<ul style="list-style-type: none"> Suitably interface and coordinate with Finishing Contractors

Item No.	Subject	Elevated Finishing Works Contractor	Telecom Contractor
4	Cable support infrastructure along the viaduct and Stations	Cable ducts/cut outs for routing telecom cables from Viaduct to Station within station area	<ul style="list-style-type: none"> Provide equipment foundations/ pedestals at equipment rooms. Install all telecom equipment, cables etc. Seal the entry/exit openings after cable installation work with fire resistant materials/cable grommet.
	T&C Stage		
5	Nil		
	O&M Stage		
6	Nil		

8.1.5 INTERFACES WITH POWER SUPPLY CONTRACTORS

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Elevated Finishing Works Contractor	Power Supply & Traction Contractor
	Design Stage		
1	ASS/TSS room	Shall design floor for loads as furnished by the Traction Contractor.	<ul style="list-style-type: none"> Shall coordinate for the room size and other associated requirements Shall furnish the equipment weight and size details to Station Building Contractor for designing floor for appropriate load.
2	Design / routing of 33 kV, 750V cables, traction return cables and SCADA cable for ETS connection	Shall take into consideration the design requirements of 33kV, 750V and other cables of PST Contractor in the station design	Shall furnish the requirements
3	Platform insulation at stations	Shall consider the requirements of PST Contractor	Shall furnish the requirements for installation of electrical insulation membrane
4	Warning and indicator boards	Shall consider the requirements of PST Contractor	Shall coordinate and inform location for provision of signboard & operating instruction boards for ETS
	C&I Stage		
5	ASS/TSS room	<ul style="list-style-type: none"> Shall provide ASS/TSS rooms compete in all respects, including flooring access doors, rolling shutters, windows and interior finish, but excluding foundations for transformer and panels. 	<ul style="list-style-type: none"> Shall coordinate for the room size and other associated requirements Alternatively, can provide suitable designed anchor fasteners for transformers, 33kV panels, 750V dc

Item No.	Subject	Elevated Finishing Works Contractor	Power Supply & Traction Contractor
		<ul style="list-style-type: none"> Shall provide the necessary cutouts for cables entry and exit from track level at any other location for traction requirement in the room. Loading/Unloading platform with Lifting hooks to be provided in per requirement of Traction Contractor Proper removable / detachable barricades / railings for loading & unloading platform to be provided in consultation with PST Contractor. No emergency staircase should infringe the loading/ unloading platform or affect movement of materials. Should ensure height of the rolling shutters are adequate for pushing in the tallest equipment Shall provide necessary foundations for transformers, panels and other equipment etc. Shall apply epoxy coating on the floor of ASS/TSS as per requirements Shall repair the structure / wall after installation of ETS 	<p>equipment, battery chargers etc. to the base floor / pedestal</p> <ul style="list-style-type: none"> Should coordinate for height of the rolling shutters are adequate for pushing in the all equipment Shall coordinate for finishing of the room and epoxy coating etc.
6	Installation of 33 kV, 750V cables, traction return cables and SCADA cable for ETS connection	<ul style="list-style-type: none"> Shall provide suitable opening and HDPE pipe for carrying cables inside ASS/TSS and for ETS as per requirement and agreed drawings. The fixing arrangement of ETS has to be provided in consultation with Traction Contractor Shall take into consideration the bending radius of cables and covering of cables in public places Shall provide suitable opening in the TSS/ASS room at appropriate location for routing the cables coming from RSS / TSS as ground to the ASS/TSS by providing a shaft from ground to the TSS/ASS room 	<ul style="list-style-type: none"> Shall supply, install & connect 33 kV, 750V cables, Traction return cables, LT power and SCADA cable for ETS connections Shall furnish the detailed cable schedule Shall interface for the cable path for 33kV, 750V cables, Traction return cables and SCADA cable for ETS connection on the station area. Shall coordinate for provisions of opening and HDPE pipes of adequate size to carry the cables indie ASS/TSS/ETS and at track crossings Shall close the opening with fire/water tight EPDM separators after installation of the cables Shall coordinate with Station Building Contractor for suitable opening in the ASS/TSS room at appropriate locations for routing the cables coming from RSS/TSS at ground to the ASS/TSS. Shall coordinate with Civil Contractor for providing a shaft from ground to the TSS/ASS room
7	Platform insulation at stations	<ul style="list-style-type: none"> Shall provide the floor suitable for installation the electrical insulation membrane 	<ul style="list-style-type: none"> Shall furnish the requirements for installation of electrical insulation membrane

Item No.	Subject	Elevated Finishing Works Contractor	Power Supply & Traction Contractor
		<ul style="list-style-type: none"> Shall accommodate Traction Contractor requirements to lay, test and commission the insulation membrane at platform as per method statement provided by Traction Contractor Shall finish the platform after installation of the insulation membrane 	<ul style="list-style-type: none"> Shall design/engineering, supply, installation, testing and commissioning include adhesive and all components for completion of the work Shall measure and certify that the insulation at the platform has been provided as per the method statement
8	Warning and indicator boards	Shall coordinate and cooperate	<ul style="list-style-type: none"> Shall coordinate and inform location for provision of signboard & operating instruction boards for ETS. Shall supply and install all warning and sign boards for each ETS Shall supply and install third rail warning and indication boards all along the viaduct, stations and depots Drawings for details of size and material will be provided by the PST Contractor for the approval of the Engineer
9	Third rail	Shall ensure that the cover of the third rail installation in station area are kept clean and shall cover the third rail installation while painting the area around the third rail	Shall interface with Finishing Contractor for cleanliness of third rail installation in the station area
10	Temporary Power for Installation, testing & commissioning	Shall provide sockets for availing temporary power at the main DB or if available, inside the ASS/TSS rooms as per requirement	<ul style="list-style-type: none"> Shall co-ordinate with Station Contractor for provision of temporary power Shall provide suitable meters for calculating the consumption Shall advise temporary power demand & required capacity and provide temporary cable Shall install the required DB with all safety features for availing the temporary power. Shall pay to the station Contractor for the power consumption <p>Note: if temporary power is not available from station Contractor, then Traction Contractor shall make his own arrangement</p>
	T&C Stage		
11	Platform insulation at stations	Shall associate for testing	Shall lead and perform the testing of the platform insulation membrane
	O&M Stage		

Item No.	Subject	Elevated Finishing Works Contractor	Power Supply & Traction Contractor
12	Nil		

8.1.6 INTERFACE WITH PSD/PSG CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Elevated Finishing Works Contractor	PSD/PSG Contractor
	Design Stage		
1	Layout of rooms at the station PSD Equipment Room	Design the finishing works of the equipment rooms in coordination and factoring in the requirements of the PSD Contractor	<ul style="list-style-type: none"> Suitably interface for marking cable Entry/Exit points and cable trenches in PSD Equipment Room on the station drawings in close coordination with the DDC/Construction/Finishing Contractor. Review design with the DDC/Construction/Finishing Contractor.
2	Cable support infrastructure at Stations	Design the finishing works in coordination and factoring in the requirements of the PSD Contractor	Shall provide the requirement of cable troughs/supports on the GAD/CSD for main cables in close coordination with the civil design and/or construction Contractor.
	C&I Stage		
3	Layout of rooms at the station PSD Equipment Rooms	<ul style="list-style-type: none"> Rooms complete with structures, false flooring, false ceiling, cable cut outs & shaft finishes, fire rated doors, cable trenches for PSD Equipment rooms Provide checkered plate for cable trench cover 	<ul style="list-style-type: none"> Suitably interface and coordinate with Finishing Contractors
4	Cable support infrastructure at Stations	Cable ducts/cut outs for routing PSD cables within station area	<ul style="list-style-type: none"> Provide equipment foundations/ pedestals at equipment rooms. Install all PSD equipment, cables etc. Seal the entry/exit openings after cable installation work with fire resistant materials/cable grommet.
	T&C Stage		
5	Nil		
	O&M Stage		
6	Nil		

8.1.7 INTERFACE WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Elevated Finishing Works Contractor	AFC Contractor
	Design Stage		
1	Layout of rooms at the station AFC Equipment Room	Design the finishing works of the equipment rooms in coordination and factoring in the requirements of the AFC Contractor	<ul style="list-style-type: none"> Suitably interface for marking cable Entry/Exit points and cable trenches in AFC Equipment Room on the station drawings in close coordination with the DDC/Construction/Finishing Contractor. Review design with the DDC/Construction/Finishing Contractor.
2	Cable support infrastructure at Stations	Design the finishing works in coordination and factoring in the requirements of the AFC Contractor	<ul style="list-style-type: none"> Shall provide the requirement of cable troughs/supports on the GAD/CSD for main cables in close coordination with the civil design and/or construction Contractor.
3	Labeling and statutory signs	Shall coordinate appropriately for other signage at stations	<ul style="list-style-type: none"> Equipment related labeling and signage on AFC equipment and cables shall be designed by AFC Contractor
	C&I Stage		<ul style="list-style-type: none">
4	Layout of rooms at the station AFC Equipment Rooms	<ul style="list-style-type: none"> Rooms complete with structures, false flooring, false ceiling, cable cut outs & shaft finishes, fire rated doors, cable trenches for AFC Equipment rooms. Provide checkered plate for cable trench cover 	<ul style="list-style-type: none"> Suitably interface and coordinate with Finishing Contractors
5	Cable support infrastructure at Stations	Cable ducts/cut outs for routing AFC cables within station area	<ul style="list-style-type: none"> Provide equipment foundations/ pedestals at equipment rooms. Install all AFC equipment, cables etc. Seal the entry/exit openings after cable installation work with fire resistant materials/cable grommet.
6	Labeling and statutory signs	Shall coordinate appropriately for other signage at stations	To do the signage under the scope of AFC Contract, specific to AFC equipment and cabling
	T&C Stage		
7	Nil		
	O&M Stage		
8	Nil		

8.1.8 INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Elevated Finishing Works Contractor	Elevator (Lift) Contractor
	Design Stage		
1	Layout of rooms at the station Lift Equipment Room	Design the finishing works of the equipment rooms in coordination and factoring in the requirements of the Lift Contractor	<ul style="list-style-type: none"> Suitably interface for marking cable Entry/Exit points and cable trenches in Telecom Equipment Room on the station drawings in close coordination with the DDC/Construction/Finishing Contractor. Review design with the DDC/Construction/Finishing Contractor.
2	Cable support infrastructure at Stations	Design the finishing works in coordination and factoring in the requirements of the Lift Contractor	<ul style="list-style-type: none"> Shall provide the requirement of cable troughs/supports on the GAD/CSD for main cables in close coordination with the civil design and/or construction Contractor.
	C&I Stage		
3	Layout of rooms at the station Lift Equipment Rooms	Rooms complete with structures, false flooring, false ceiling, cable cut outs & shaft finishes, fire rated doors, cable trenches for Lift Equipment rooms	<ul style="list-style-type: none"> Suitably interface and coordinate with Finishing Contractors Provide checkered plate for cable trench cover
4	Cable support infrastructure at Stations	Cable ducts/cut outs for routing Lift cables within station area	<ul style="list-style-type: none"> Provide equipment foundations/ pedestals at equipment rooms. Install all Lift equipment, cables etc. Seal the entry/exit openings after cable installation work with fire resistant materials/cable grommet.
	T&C Stage		
5	Nil		
	O&M Stage		
6	Nil		

8.1.9 INTERFACE WITH ESCALATOR CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Elevated Finishing Works Contractor	Escalator Contractor
	Design Stage		

Item No.	Subject	Elevated Finishing Works Contractor	Escalator Contractor
1	Layout of rooms at the station Escalator Equipment Room	Design the finishing works of the equipment rooms in coordination and factoring in the requirements of the Escalator Contractor	<ul style="list-style-type: none"> Suitably interface for marking cable Entry/Exit points and cable trenches in Escalator Equipment Room on the station drawings in close coordination with the DDC/Construction/Finishing Contractor. Review design with the DDC/Construction/Finishing Contractor.
2	Cable support infrastructure at Stations	Design the finishing works in coordination and factoring in the requirements of the Escalator Contractor	Shall provide the requirement of cable troughs/supports on the GAD/CSD for main cables in close coordination with the civil design and/or construction Contractor.
	C&I Stage		
3	Layout of rooms at the station Escalator Equipment Rooms	Rooms complete with structures, false flooring, false ceiling, cable cut outs & shaft finishes, fire rated doors, cable trenches for Escalator Equipment rooms	Suitably interface and coordinate with Finishing Contractors Provide checkered plate for cable trench cover
4	Cable support infrastructure at Stations	Cable ducts/cut outs for routing Escalator cables within station area	<ul style="list-style-type: none"> Provide equipment foundations/ pedestals at equipment rooms. Install all escalator equipment, cables etc. Seal the entry/exit openings after cable installation work with fire resistant materials/cable grommet.
	T&C Stage		
5	Nil		
	O&M Stage		
6	Nil		

8.1.10 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 2.1.14 above](#) shall apply as relevant to the context

CHAPTER 9

9.0 UNDERGROUND FINISHING WORKS CONTRACTORS' INTERFACES

9.1.1 INTERFACE WITH UG CIVIL CONTRACTOR

Refer [Para 3.1.4 above](#)

9.1.2 INTERFACE WITH UG E&M CONTRACTOR

Refer [Para 6.1.2 above](#)

9.1.3 INTERFACE WITH SIGNALING & TRAIN CONTROL (S&TC) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions apply as for elevated stations – refer [Para 8.1.3 above](#)

9.1.4 INTERFACE WITH TELECOMMUNICATION (TEL) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions apply as for elevated stations – refer [Para 8.1.4 above](#)

9.1.5 INTERFACES WITH POWER SUPPLY CONTRACTORS

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions apply as for elevated stations – refer [Para 8.1.5 above](#)

9.1.6 INTERFACE WITH PSD/PSG CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions apply as for elevated stations – refer [Para 8.1.6 above](#)

9.1.7 INTERFACE WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions apply as for elevated stations – refer [Para 8.1.7 above](#)

9.1.8 INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions apply as for elevated stations – refer [Para 8.1.8 above](#)

9.1.9 INTERFACE WITH ESCALATOR CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions apply as for elevated stations – refer [Para 8.1.9 above](#)

9.1.10 INTERFACE WITH TVS CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	UG Finishing Works Contractor	TVS Contractor
Design Stage			
1	Layout of rooms at the station TVS Equipment Room	Design the finishing works of the equipment rooms in coordination and factoring in the requirements of the TVS Contractor	<ul style="list-style-type: none"> Suitably interface for marking cable Entry/Exit points and cable trenches in TVS Equipment Room on the station drawings in close coordination with the DDC/Construction/Finishing Contractor. Review design with the DDC/Construction/Finishing Contractor.
2	Cable support infrastructure at Stations	Design the finishing works in coordination and factoring in the requirements of the TVS Contractor	Shall provide the requirement of cable troughs/supports on the GAD/CSD for main cables in close coordination with the civil design and/or construction Contractor.
C&I Stage			
3	Layout of rooms at the station TVS Equipment Rooms	Rooms complete with structures, false flooring, false ceiling, cable cut outs & shaft finishes, fire rated doors, cable trenches for TVS Equipment rooms	<ul style="list-style-type: none"> Suitably interface and coordinate with Finishing Contractors Provide checkered plate for cable trench cover

Item No.	Subject	UG Finishing Works Contractor	TVS Contractor
4	Cable support infrastructure at Stations	Cable ducts/cut outs for routing TVS cables within station area	<ul style="list-style-type: none"> Provide equipment foundations/ pedestals at equipment rooms. Install all TVS equipment, cables etc. Seal the entry/exit openings after cable installation work with fire resistant materials/cable grommet
5	Equipment room finishing	Shall finish the floors with Epoxy paint and walls with anti-dust paint for TVS room, TES Room, TVS Shafts and TES shafts as per CSD	Shall provide the details and monitor
	T&C Stage		
6	TVS system testing and commissioning	Shall cooperate and support the testing and commissioning activities of the TVS system	Shall lead the testing and commissioning activities of TVS system
	O&M Stage		
7	TVS system O&M	Shall cooperate and support the O&M activities of the TVS system	Shall lead the O&M activities of TVS system

9.1.11 INTERFACE WITH ECS CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	UG Finishing Works Contractor	ECS Contractor
	Design Stage		
1	Layout of rooms at the station ECS Equipment Room	Design the finishing works of the equipment rooms in coordination and factoring in the requirements of the ECS Contractor	Suitably interface for marking cable Entry/Exit points and cable trenches in ECS Equipment Room on the station drawings in close coordination with the DDC/Construction/Finishing Contractor. Review design with the DDC/Construction/Finishing Contractor.
2	Cable support infrastructure at Stations	Design the finishing works in coordination and factoring in the requirements of the ECS Contractor	Shall provide the requirement of cable troughs/supports on the GAD/CSD for main cables in close coordination with the civil design and/or construction Contractor.
	C&I Stage		
3	Layout of rooms at the station ECS Equipment Rooms	Rooms complete with structures, false flooring, false ceiling, cable cut outs & shaft finishes, fire rated doors, cable trenches for ECS Equipment rooms	<ul style="list-style-type: none"> Suitably interface and coordinate with Finishing Contractors Provide checkered plate for cable trench cover
4	Cable support infrastructure at Stations	Cable ducts/cut outs for routing ECS cables within station area	<ul style="list-style-type: none"> Provide equipment foundations/ pedestals at equipment rooms.

Item No.	Subject	UG Finishing Works Contractor	ECS Contractor
			<ul style="list-style-type: none"> Install all ECS equipment, cables etc. Seal the entry/exit openings after cable installation work with fire resistant materials/cable grommet.
5	Equipment room finishing	Shall finish the floors, shafts with Epoxy paint and walls with anti-dust paint as per CSD	Shall monitor
	T&C Stage		
6	ECS system testing and commissioning	Shall cooperate and support the testing and commissioning activities of the ECS system	Shall lead the testing and commissioning activities of ECS system
	O&M Stage		
7	ECS system O&M	Shall cooperate and support the O&M activities of the ECS system	Shall lead the O&M activities of ECS system

9.1.12 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 2.1.14 above](#) shall apply as relevant to the context

CHAPTER 10

10.0 DEPOT FINISHING WORKS CONTRACTORS' INTERFACES

10.1.1 INTERFACE WITH DEPOT CIVIL CONTRACTOR

Refer [Para 4.1.4 above](#)

10.1.2 INTERFACE WITH UG E&M CONTRACTOR

Refer [Para 7.1.2 above](#)

10.1.3 INTERFACE WITH SIGNALING & TRAIN CONTROL (S&TC) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Depot Finishing Works Contractor	S&TC Contractor
	Design Stage		
1	Layout of rooms at the depot – SER / CER, UPS room and Depot control rooms	Design the finishing works of the DCC and equipment rooms in coordination and factoring in the requirements of the S&TC Contractor	<ul style="list-style-type: none"> Suitably interface for marking cable Entry/Exit points and cable trenches on the drawings in close coordination with the DDC/Construction/Finishing Contractor. Review design with the DDC/Construction/Finishing Contractor.
2	Depot Control Center	Shall design the finishing works of Depot Control Centre	Furnish layout of Signalling equipment within Depot Control Centre in close coordination with the DDC/Construction/Finishing Contractor.
	C&I Stage		
3	Layout of rooms at the depot – SER / CER, UPS room and Depot control rooms	False flooring in the Signalling equipment room, false ceiling if necessary, finishes, checkered plate for cable trench in UPS rooms, fire rated doors, finishing for Cut outs provided for cable entry.	Coordinate closely with construction / finishing Contractor to ensure the requirements at site are met.
4	Depot Control Center	Shall carryout the finishing works in Depot Control Centre	Provide furniture for all Systems; provide UPS supply for workstations for all systems including suitable protection arrangement in UPS room and install Signalling equipment within Depot Control Centre including cable tray provision for Signalling equipment.
	T&C Stage		

Item No.	Subject	Depot Finishing Works Contractor	S&TC Contractor
5	Nil		
	O&M Stage		
6	Nil		

10.1.4 INTERFACE WITH ROLLING STOCK CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Depot Finishing Works Contractor	Rolling Stock Contractor
	Design Stage		
1	Layout of RS rooms and other RS related occupancies at the depot	Design the finishing works of the DCC and equipment rooms / other occupancies in coordination and factoring in the requirements of the RS Contractor	<ul style="list-style-type: none"> Suitably interface and mark appropriately RS related requirements on the drawings in close coordination with the DDC/Construction/Finishing Contractor. Review design with the DDC/Construction/Finishing Contractor.
	C&I Stage		
2	Layout of RS rooms and other RS related occupancies at the depot	Provide rooms and other occupancies with finishes as agreed and as required	Coordinate closely with construction / finishing Contractor to ensure the requirements at site are met.
	T&C Stage		
3	Nil		
	O&M Stage		
4	Nil		

10.1.5 INTERFACE WITH TELECOMMUNICATION (TEL) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Depot Finishing Works Contractor	Telecom Contractor
	Design Stage		
1	Layout of Telecom Equipment rooms at the depot	Design the finishing works of the equipment rooms in coordination and factoring in the requirements of the Telecom Contractor	<ul style="list-style-type: none"> Suitably interface for marking cable Entry/Exit points and cable trenches on the drawings in

Item No.	Subject	Depot Finishing Works Contractor	Telecom Contractor
			close coordination with the DDC/Construction/Finishing Contractor. <ul style="list-style-type: none"> Review design with the DDC/Construction/Finishing Contractor.
	C&I Stage		
2	Layout of Telecom Equipment rooms at the depot	False flooring in the Telecom equipment room, false ceiling if necessary, finishes, checkered plate for cable trench in equipment rooms, fire rated doors, finishing for Cut outs provided for cable entry	Coordinate closely with construction / finishing Contractor to ensure the requirements at site are met.
	T&C Stage		
3	Nil		
	O&M Stage		
4	Nil		

10.1.6 INTERFACES WITH POWER SUPPLY CONTRACTORS

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions, as relevant, apply– refer [Para 8.1.5 above](#)

10.1.7 INTERFACE WITH PSD/PSG CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions, if PSD is installed in depot / test track, apply as for elevated stations – refer [Para 8.1.6 above](#)

10.1.8 INTERFACE WITH AUTOMATIC FARE COLLECTION (AFC) SYSTEM CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same/similar provisions, as relevant, apply as for elevated stations for AFC related rooms in depot – refer [Para 8.1.7 above](#)

10.1.9 INTERFACE WITH ELEVATOR (LIFT) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions, as relevant, apply as for elevated stations – refer [Para 8.1.8 above](#)

10.1.10 INTERFACE WITH ESCALATOR CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Same provisions, as relevant, apply as for elevated stations – refer [Para 8.1.9 above](#)

10.1.11 INTERFACE WITH M&P CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Depot Finishing Works Contractor	M&P Contractor
	Design Stage		
1	Layout of M&P rooms/areas and other M&P related occupancies at the depot	Design the finishing works of the DCC and equipment rooms / other occupancies in coordination and factoring in the requirements of the M&P Contractor	<ul style="list-style-type: none"> Suitably interface and mark appropriately M&P related requirements on the drawings in close coordination with the DDC/Construction/Finishing Contractor. Review design with the DDC/Construction/Finishing Contractor.
	C&I Stage		
2	Layout of M&P rooms/areas and other M&P related occupancies at the depot	Provide rooms and other occupancies with finishes as agreed and as required	Coordinate closely with construction / finishing Contractor to ensure the requirements at site are met.
	T&C Stage		
3	Nil		
	O&M Stage		
4	Nil		

10.1.12 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 2.1.14 above](#) shall apply as relevant to the context

CHAPTER 11

11.0 SIGNALING & TRAIN CONTROL (S&TC) SYSTEM INTERFACES

11.1.1 INTERFACES WITH ELEVATED CIVIL CONTRACTORS

Refer to [Para 2.1.5 above](#)

11.1.2 INTERFACES WITH UNDERGROUND CIVIL CONTRACTORS

Refer to [Para 3.1.5 above](#)

11.1.3 INTERFACES WITH DEPOT CIVIL CONTRACTORS

Refer to [Para 4.1.5 above](#)

11.1.4 INTERFACES WITH ELEVATED E&M CONTRACTORS

Refer to [Para 5.1.3 above](#)

11.1.5 INTERFACES WITH UNDERGROUND E&M CONTRACTORS

Refer to [Para 6.1.3 above](#)

11.1.6 INTERFACES WITH DEPOT E&M CONTRACTORS

Refer to [Para 7.1.3 above](#)

11.1.7 INTERFACES WITH ELEVATED FINISHING WORKS CONTRACTORS

Refer to [Para 8.1.3 above](#)

11.1.8 INTERFACES WITH UNDERGROUND FINISHING WORKS CONTRACTORS

Refer to [Para 9.1.3 above](#)

11.1.9 INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS

Refer to [Para 10.1.3 above](#)

11.1.10 INTERFACES WITH ROLLING STOCK (RS) CONTRACTOR (DTG SIGNALLING SYSTEM)

Definitions and Scope

11.1.10.1 This section describes the interface requirements between S&TC Contractor and the Rolling Stock Contractor for Phase 1 Extension Corridors.

11.1.10.2 The S&TC and Rolling Stock Contractors shall ensure that all requirements of the specification pertaining to interfaces are comprehensively satisfied.

Details of Contractors

11.1.10.3 The train sets being procured with Distance-to-Go (DTG) based signaling system shall operate on Phase 1 and its four extensions line under Phase II.

11.1.10.4 DTG based signaling system of Phase-I and four extensions lines will be of the same type and will have similar interface between Rolling Stock and Signaling. The Rolling Stock and S&TC interface for the new trains procured under Rolling Stock Contract shall be almost same as that of interface of Rolling Stock with S&TC system of Phase 1 except few minor changes as detailed herein.

- 11.1.10.5 Rolling Stock Contractor and Signalling & Train Control Contractor shall ensure complete integration of their respective equipment with the Interface requirements among these systems and also ensure that any new equipment is fully backward compatible with the existing system and with equipment which has already been identified and finalized for the relevant extension lines / sections. For example, the Rolling Stock Contractor shall ensure that the trains procured under RS Contract designated for Line 1 and Line 2 including four extensions are compatible with the Signalling & Train Control Systems as provided under the Phase 1 S&TC Contract, similarly the S&TC Contractor shall ensure compatibility of the S&TC system with new train-sets shall be similar to the compatibility of S&TC system of Phase 1 S&TC Contract with Phase 1 RS Contract except some minor changes as detailed herein.
- 11.1.10.6 While the existing interface requirements as finalized, generally meet the requirements described in the following clauses, Detailed Interface Documents have already been developed for these interfaces for Line 1 and Line 2, which shall be used as baseline documents. The Contractors shall take the advancement in technology, communication protocols, physical media of transmission and operational requirements for new trains into consideration and appropriately provide interfacing requirements.
- 11.1.10.7 It shall be ensured by S&TC Contractor that door authorization signal is provided only after completion of ATC cab change over process, in case ATC changeover is in progress and train stops at platform stopping position during this process.

Train Operating Modes

11.1.10.8 General System Descriptions

- (i) The train-borne Automatic Train Control (ATC) system will consist of an Automatic Train Protection (ATP) system and an Automatic Train Operation (ATO) system on Line 1 and Line 2 including extensions.
- (ii) The Rolling Stock required for Line1 & Line 2 including extensions shall be fitted with ATO and redundant ATP systems, complete in all respects.
- (iii) The supply/delivery of Automatic Train Control (ATC) System for new trains shall be responsibility of the Contractors for Signalling & Train Control for the respective extension lines and shall be required to liaise closely with the Rolling Stock Contractor, in regard to the installation, testing and commissioning of the Signalling & Train Control Equipment.

11.1.10.9 ATO Mode

The on-board equipment shall provide for Automatic Train Operation (ATO) on Line 1 & 2 including four extensions. In this mode, the train's speed, motoring, coasting and braking within the parameters dictated by the ATP system shall be performed by the on-board equipment without the train operator's intervention. This operation shall include:

- (i) Automatic operation of trains between stations;
- (ii) Receipt of coasting request and passing of request to traction power equipment and also provide for acceleration and deceleration of the train;
- (iii) Automatic stopping of trains at platforms within a tolerance of $\pm 500\text{mm}$ for 99.98% or $\pm 300\text{mm}$ for 99.5% of station stops; it shall be the same as implemented in Signalling & Train Control Contract of Phase-I.
- (iv) Automatic opening of doors on the appropriate platform side(s) when the train is berthed;
- (v) Prevent the train from starting if the train doors are detected not closed and locked; and
- (vi) Receipt and implementation of control to skip one or more stations.

The trains under ATO operation shall always remain under ATP protection. Transfer from ATP to ATO mode shall only be possible at standstill at a station stopping point; however, transfer from ATO to ATP mode shall be possible at any time at standstill.

11.1.10.10 **ATP (or Coded Manual) Mode**

The on-board equipment shall provide Automatic Train Protection (ATP) on all lines/sections. In this mode, the control of the train speed and braking within the parameters dictated by the ATP system, shall be performed by the train operator.

The ATP mode shall include:

- (i) Identification and enforcement of maximum safe speed at which the train may operate, as deduced from the most restricting ATP condition;
- (ii) Identification and display of actual speed, target speed, target distance, and the maximum safe speed;
- (iii) Identification and audible and visual warning when train is operating at a speed higher than the maximum safe speed. The equipment to provide audible and visible warnings shall be provided by respective Signalling & Train Control Contractor;
- (iv) Provision of an audible and visual warning to the train operator, when the system identifies that the train is operating at a speed in excess of the maximum safe speed and a pre-determined delay of 2 sec for the train operator to react. If the driver fails to reduce the speed below the maximum safe speed in a specified time a service brake application shall be applied to the train. In the event of the service braking rate being inadequate, an irrevocable Emergency Brake application shall be applied automatically;
- (v) Identifying the platform side of the train with the train berthed at a station. The system shall then enable the doors to be opened on that side upon completion of ATC changeover from rear to front, in any; and
- (vi) Receipt of a door closed signal indicating that all doors are closed and locked before the train may start. Loss of this signal shall cause the ATP system to initiate an emergency brake application.

11.1.10.11 **Restricted Manual Forward Mode (RMF) and Run On Sight Mode (ROS)**

- (a) In RM mode, principally for use in depots and on mainline in case of failure of the wayside signalling, the maximum train speed shall be controlled by the on-board ATP. This limit may be configurable to a speed determined to be safe for unsupervised driving between 15kmph and 25kmph. This mode shall be available only when the on-board ATP equipment is operational. The RM mode shall be operational with mode selector in the RMF position.
- (b) The train operator shall be given a warning, both audio and visual when the speed is above RM threshold but below 25 Kmph.
- (c) In Restricted Manual Mode the train operator shall be able to control Trains door when the Train is stopped within the station stopping limits.
- (d) In ROS mode of operation, the train operator Runs On Sight. ROS mode shall be selected by a ROS button/ Key with the mode selector in ATP position. ATP authorizes ROS request. In ROS mode, the train speed shall be controlled by the on-board ATP as in the case of RM mode. ATP shall give cab signal indications as soon as the train reaches a track position where normal running can be resumed.
- (e) The ROS driving mode will be unselected and will automatically switch from ROS to ATP with no brake application.

11.1.10.12 **Restricted Manual Reverse (RMR) Mode**

Reverse operation shall be possible by bringing the Mode Selector in RMR position with ATP protection. It shall be possible to run in reverse direction under ATP protection on mainline.

The maximum permissible speed of the train shall not exceed 10kmph in reverse mode for a predefined distance. This predefined distance shall be designed by the Contractor and submitted to the Engineer for Approval.

11.1.10.13 **Standby Mode**

A fully initiated train in standstill condition. Traction control shall be inoperative and brake shall be applied during this mode. This mode will be used for testing the door in depot. The Contractor shall submit the detail of mode during design stage.

11.1.10.14 **Manual Cutout (or Bypass) Mode**

By-pass Mode shall be provided for use in the event of failure of the ATP system. In this mode, the train speed shall be controlled entirely by the train operator, to a limit adjustable between 15 kmph and 25 kmph. Rolling Stock Contractor shall provide equipment and means to ensure that the maximum train speed remains within the above limit when the Cut-out Mode is in effect, under all circumstances. In case speed of the train exceeds 25kmph, 70% FSB shall be applied by Rolling Stock.

The ATP By-pass Mode shall be initiated by the train operator operating a sealed Safety Cut-out Switch (SCS) and simultaneously breaking its seal. The operation shall be recorded by the on-board digital counter and TCMS. The SCS shall be provided by Rolling Stock Contractor. The on-board digital counter shall be provided by the signalling Contractor. In this mode the train doors shall only be enabled and controlled manually.

11.1.10.15 **Washing and coupling mode**

In Wash coupling mode, the speed is between 3 kmph to 5 kmph to prevent any damages of the automatic washing machine equipment and for safety reasons. Wash/Coupling mode will be selected through TCMS with SCS switch in Normal position with Mode selector in RMF position.

11.1.10.16 **Identification: Train Operating Mode, Train Decryption and Next Station Information**

11.1.10.16.1 The Signalling & Train Control Contractor shall provide a four-digit Train Identification Number (Train ID) to the Rolling Stock Contractor. The first two digits shall identify a destination while the second two digits shall be a service identifier. The destination codes shall signify unique routes. The RS Contractor shall accordingly use the relevant information such as names of intermediate stations, stopping pattern, station stop door opening side information etc. for operation of on-train systems.

11.1.10.16.2 The Train ID shall be allocated to train when it enters the service and shall be maintained until it finishes its service. It should be possible by the Employer to amend and / or modify the Train ID, subsequently, to suit the operational requirements. The Signalling & Train Control and Rolling Stock Contractors should provide necessary equipment and means for the same.

11.1.10.16.3 The Rolling Stock Contractor and the Signalling & Train Control Contractor shall exchange information for identifying the effective mode, the active or non-active status of each cab, the door status etc. The inputs shall be categorized as vital and non-vital. The levels and form of these inputs shall be coordinated between the two Contractors.

11.1.10.16.4 Not used

- 11.1.10.16.5 The Rolling Stock Contractor shall log each time the mode is changed using the on-board TCMS (Train Control Management System) equipment.
- 11.1.10.16.6 In By-pass or Cut-out Mode, an external indication light shall flash or occult.
- 11.1.10.16.7 The Signalling & Train Control Contractor shall provide the necessary input signals (next station information code, platform side information, triggering signal, departure bit, arrival bit, platform destination bit etc.) to Rolling Stock for displaying and making next station announcements to passengers on-board. Rolling Stock Contractor shall provide the necessary hardware. Levels and protocols shall be agreed between the Contractors.
- 11.1.10.16.8 For ATO operation, the necessary train command inputs including that for the PWM signal shall be provided by the Signalling & Train Control Contractor. For all ATP/ATO initiated PWM signal demands, redundancy shall be provided using the TCMS (Train Control Management System). The levels and form of these inputs shall be coordinated between the two Contractors.

Interface Requirements between S&TC and RS Contractors

11.1.10.17 General

- 11.1.10.17.1 The Signalling & Train Control Contractor shall provide the Rolling Stock Contractor with the final list of equipment to be provided on the rolling stock. The sizes and weights of the ATO/ATP on-board cab equipment and antennae etc. to be mounted on the Rolling Stock shall also be provided, as applicable.
- 11.1.10.17.2 The Signalling & Train Control Contractor shall deliver to the Rolling Stock Contractor's factories, all train-borne ATC equipment, as applicable, and data to enable fitting and testing.
- 11.1.10.17.3 The Signalling & Train Control Contractor shall supply at Rolling Stock Contractor's factories pre-wired equipment racks with appropriate connectors for all wiring terminating inside ATC, including wiring between ATC racks. The Signalling & Train Control Contractor with the details provided by the Rolling Stock Contractor shall ensure that the exterior finish and colours of the respective equipment suitably harmonize with that of the cab and the vicinity.
- 11.1.10.17.4 Interfacing wiring for each module provided by the Signalling & Train Control Contractor including the interfacing wiring between the Signalling & Train Control equipment shall terminate in a quick disconnect robust plug connector suitable for traction applications, with direct cable connection as far as possible. All cable connectors shall be identified within the cubicle using robust cable markers with distinctive colours for identification of e.g. safety function cables.
- 11.1.10.17.5 For all relay contact interfaces the Signalling & Train Control Contractor shall provide auto-contact jam detection and contact bounce elimination function to ensure proper operation of the system. Relays for safety functions shall comply with the appropriate internationally accepted standard specification.
- 11.1.10.17.6 The Signalling & Train Control Contractor shall provide the Rolling Stock Contractor with the number of wires / communication architecture and protocols required between cars of a married pair and between married pairs to transmit signals from one end of the rake to the other end through an electrical jumper.
- 11.1.10.17.7 For compatibility, the Rolling Stock and the train detection system (track circuits), shall conform to EN 50238.
- 11.1.10.17.8 Vehicle control circuits shall be developed by the Rolling Stock Contractor. During the design stage, all vehicle control circuits incorporating the identified interfaces shall be provided to the Signalling & Train Control Contractor, as applicable. The

Signalling & Train Control Contractor shall provide specific observations on these circuits to the Rolling Stock Contractor. The Rolling Stock Contractor shall suitably incorporate any (if applicable) observations in the design.

11.1.10.17.9 Certain vital and non-vital signals from ATC side shall be monitored by TCMS. These details shall be discussed and finalized during design stage. However, it shall be the responsibility of Signalling Contractor to provide reading tool to read the ATC data stored in TCMS.

11.1.10.18 **Rolling Stock Characteristics to be used by S&TC Contractor**

11.1.10.18.1 The train procured under this Contract shall run on the Phase-I corridors and interface decided between Rolling Stock and Signalling for Phase-I shall be maintained.

11.1.10.18.2 The size and location of track circuits for determining the ATP blocks shall be designed to meet the headway requirements of 3-car & 6-car consists, based on the characteristics of the vehicles to be furnished and the track geometry. The fixed line-side signals (used in cut out mode) shall use the same track circuits as designed for the ATP working. The signal designer must co-ordinate with the Rolling Stock supplier to fine-tune the block design based on the traction and braking characteristics of the actual vehicles furnished. Acceptance tests of the signal system will use the actual vehicles supplied.

11.1.10.18.3 When operating in ATP Mode, a delay of 2 sec (programmable) shall be provided for the train operator to acknowledge a reduction in speed and begin to apply the brakes.

11.1.10.18.4 The model for calculating the Safe Braking Distance (SBD) shall identify and take into account various systems' response times and train operators' reaction times. The design of ATP blocks shall also take into account the effect of track geometry on the traction and braking characteristics. The Rolling Stock Contractor shall furnish the guaranteed braking rate at the normal braking efficiency, and at the lowest braking efficiency permitted in service, including brake deterioration, to the Signalling & Train Control Contractor. Rolling Stock Contractor shall provide the speed/time curves between stations and speed/ tractive effort curves, for all loading conditions.

11.1.10.18.5 The Rolling Stock Contractor shall furnish as a minimum the Rolling Stock parameters to be used by the Signalling & Train Control Contractor for designing the target distance-based ATP system, as set out in [Para 0 below](#) (Rolling Stock Characteristics). The Rolling Stock Contractor shall also furnish a reasonable tolerance band for the identified performance parameters. The Rolling Stock Contractor shall ensure that all the trains supplied perform within the tolerance band.

11.1.10.18.6 For any other information required by the Signalling & Train Control Contractor, he shall co-ordinate with the Rolling Stock Contractor.

11.1.10.19 **S&TC details to be used by RS Contractor**

The following data shall be provided:

- (i) The maximum power consumed by the Signalling & Train Control Contractor equipment from the 110V DC. Supply under all specified operating conditions;
- (ii) The number of train wires required and the specific function of each wire/communication architecture and protocols;
- (iii) All control logic outputs;
- (iv) Electrical characteristics of the interconnection cabling and wiring;
- (v) Sensitivity levels and frequencies which must be avoided;
- (vi) The specific heat load for air conditioning purposes;

- (vii) Specific ventilation requirements if any;
- (viii) The EMC/EMI requirements including the limiting value of photometric current, to obviate interference in the operation of telecommunication equipment; and
- (ix) Details of the provisions required to enable the transference of data from the train to the OCC.

11.1.10.20 **ATC Equipment Cubicles**

11.1.10.20.1 The Rolling Stock Contractor shall supply the ATC equipment cubicle enclosure(s). All supports, braces, mounting holes, cabling apertures, accessories, etc. required for mounting the cubicle and its equipment shall be properly coordinated between the Signalling & Train Control Contractor and the Rolling Stock Contractors to ensure secure mounting, and access. The cubicle(s) shall be resiliently mounted.

11.1.10.20.2 To achieve the ATC control functions, the Signalling & Train Control Contractor shall identify any interfacing circuits specifically required for ATC operation and liaise with the Rolling Stock Contractor. These shall include but not be limited to start, door control, motoring, coasting, braking and emergency brake commands.

11.1.10.20.3 For train control circuits the Signalling & Train Control Contractor shall respectively identify the voltage free contacts to be provided by the Rolling Stock Contractor, including the number and type of electrical signals required between the ATP/ATO equipment and the equipment provided by the Rolling Stock Contractor. The two Contractors shall co-ordinate to agree on levels and protocols for each such signal.

11.1.10.20.4 As a minimum, all electronic equipment to be mounted on rolling stock, including those provided by the Signalling & Train Control Contractor shall comply with IEC 60571: Electronic Equipment used on Rail Vehicles, for design, manufacture and testing, and shall use components purchased against an internationally recognized quality assurance and reliability certification procedure.

11.1.10.21 **Antennae**

11.1.10.21.1 The Signalling & Train Control Contractor shall identify all roof, bogie, and under-frame mounted antennae, and associated disconnection box mounting brackets and location requirements to identify cable and conduit routes required to antennae, as applicable.

11.1.10.21.2 The Signalling & Train Control Contractor for their respective scope shall supply the necessary disconnection boxes, terminal blocks, cables and adaptation mounting brackets, flexible conduit assemblies complete with connectors and cables from antennae to the junction boxes.

11.1.10.21.3 The Rolling Stock Contractor shall provide the antenna mounting brackets, conduits, support or clamping arrangements, fixtures and accessories to ensure security and reliability.

11.1.10.21.4 The Antenna system shall not infringe upon the kinematic envelop and fully meets the requirements, both for normal and reverse direction of train working.

11.1.10.22 **Speed Measurement Devices**

11.1.10.22.1 For each ATC equipment set (per driving cab), the Signalling & Train Control Contractor shall supply to the Rolling Stock Contractor for installation, axle mounting speed measurement devices and couplings, to be configured, and the data from them processed in such a way as to achieve the objectives described below in fail safe manner.

The speed measurement device shall be mounted on axles of those bogies, which are non-powered but service and friction braked.

11.1.10.22.2 The Signalling & Train Control Contractor shall ensure that the speed measurement devices produce a signal which reflects the true speed of the train (within ± 1.0 km/hr) under any operational, weather and track conditions including gradient, curvature, wheel spin/slide and error in the speed measurement due to wear in wheel diameter.

11.1.10.22.3 The Signalling & Train Control Contractor shall supply the necessary disconnection and terminal blocks, flexible conduit assemblies complete with connectors and cables from speed measurement devices to the junction boxes. The Speed Measurement device will be supplied by Signalling & Train Control Contractor. Any mechanical items for fixing these devices shall be supplied by the Signalling & Train Control Contractor.

11.1.10.22.4 The Rolling Stock Contractor shall provide for each speed measurement device mounting brackets, support or clamping arrangements to ensure security and reliability.

11.1.10.22.5 The Signalling & Train Control Contractor shall furnish the zero-velocity detection apparatus (ZVR relay).

11.1.10.22.6 The Signalling & Train Control Contractor shall provide speedometer indicating the actual speed, and with maximum safe speed. The design shall be acceptable to the Engineer.

11.1.10.22.7 The Automatic Train Protection (ATP) system shall issue the braking commands to the Rolling Stock when safety limits are exceeded or when over-speed is detected. Removal of traction power and the correct application of brakes shall be the responsibility of the Rolling Stock Contractor. The ATP system shall be responsible for monitoring of speed and the issuing of braking commands when safety limits are exceeded.

11.1.10.22.8 Parking brakes shall be provided by the Rolling Stock Contractor. The parking brakes shall be capable of holding a fully loaded stationary train on a 4% gradient under all track conditions, indefinitely.

11.1.10.22.9 The Signalling & Train Control Contractor shall furnish the Rolling Stock Contractor with full mounting details, apertures, fixing holes, etc.

11.1.10.23 Train Operator's Display

Indications to the train operator shall be displayed on the ATC Cab Display supplied by the Signalling & Train Control Contractor. It shall incorporate as a minimum, but not be limited to the following information:

- (i) Train description, (ID) including crew identification;
- (ii) Target Distance;
- (iii) Target Speed;
- (iv) Service and Emergency Brake Initiation;
- (v) Train docked;
- (vi) Train hold status;
- (vii) Station dwell time available;
- (viii) Departure order;
- (ix) In ATP zone or not;
- (x) ATP/ATO failure indications;
- (xi) Skip Stop indication;
- (xii) Door Open Indication;
- (xiii) Maximum Permissible Safe Speed (MSS) in ATP and ATO Modes;
- (xiv) Train stopped outside of expected stopping window;
- (xv) Depot indication, when the train is identified as being in a depot;

- (xvi) Axle locked indication, for axles on which ATC speed sensors;
- (xvii) Door release available; indicating on which side(s) of the train the doors may be opened; and
- (xviii) Operating Mode

11.1.10.24 **Interface between the TCMS and Train Control Equipment**

11.1.10.24.1 Train Control Management System (TCMS), to log the information from the ATP/ATO equipment supplied by the Signalling & Train Control Contractor in addition to the information shown in the Rolling Stock specification. The Signalling & Train Control Contractor shall provide the reading tool for ATC data stored in TCMS.

11.1.10.24.2 Data stored in the TCMS shall be password protected. Levels and protocols shall be agreed between the Contractors. Software for downloading the data from the TCMS to the maintenance terminal shall be provided by the Rolling Stock Contractor. The Signalling & Train Control Contractor shall provide Windows compatible software for maintenance terminals for viewing the data logged in the TCMS.

11.1.10.24.3 All vital commands transmitted by the on-board ATP and ATO systems to the Rolling Stock equipment and the respective responses of the Rolling Stock equipment to these commands, shall also be recorded in the TCMS.

11.1.10.24.4 The signals to be supplied from the TCMS to the equipment of Signalling & Train Control Contractor shall be decided jointly between the Contractors.

11.1.10.24.5 Not Used

11.1.10.24.6 The interface shall ensure that the TCMS receive necessary inputs from the on-board ATP system to enable the TCMS to synchronize its clock with the system master clock. All the microprocessor/ micro-controller based on-train systems shall synchronize their respective clocks with the TCMS clock.

11.1.10.24.7 Rolling Stock Contractor to ensure that all signal inputs received from Signalling & Train Control equipment and output signals exported to Signalling & Train Control equipment shall be recorded and shall be available for retrieval for analysis/record. All signals (import/export between Rolling Stock & Signalling & Train Control) shall be monitored through TCMS. Signalling & Train Control Contractor shall interface with RS Contractor to finalize the necessary format in which the data will be captured by TCMS and shall also provide necessary reading tools to read this data from TCMS.

11.1.10.25 **Power Supply and Earthing Arrangements**

11.1.10.25.1 The Rolling Stock Contractor shall provide independent 110V DC power supply circuits/Power supply requirement as per interface document including positive and negative poles. At least three power supplies for the ATC Equipment shall be provided by the Rolling Stock Contractor and there shall be no physical or electrical links between these power supply circuits.

11.1.10.25.2 The Rolling Stock Contractor shall provide dedicated earthing arrangements for the train borne ATC equipment. The Signalling & Train Control Contractor shall specify the earth impedance required.

11.1.10.25.3 The power supply cable between the train power supply and the ATC train borne equipment power equipment shall be segregated, and shall be as short as possible and directly connected to the supply without any intermediate connection.

11.1.10.26 **Factory Installation and Testing**

- 11.1.10.26.1 All the special equipment associated with the train borne ATC system, including the interface cables / wires shall be designed and supplied by the Signalling & Train Control Contractor to the Rolling Stock Contractor's premises. Each Contractor shall be aware of the locations of the respective manufacturing plants.
- 11.1.10.26.2 The Signalling & Train Control Contractor shall be responsible for providing all data and training of the Rolling Stock Contractor's staff in all aspects of the ATC installation and testing where applicable. The first set of ATC equipment shall be installed by the Rolling Stock Contractor, under the supervision of the Signalling & Train Control Contractor's representatives.
- 11.1.10.26.3 The Rolling Stock Contractor shall be responsible for the installation of wiring for equipment, and its testing on each car to the functioning standard agreed with the Signalling & Train Control Contractor.
- 11.1.10.26.4 The Testing of each car shall comply with accepted international standards agreed between the Contractors and agreed with the Engineer. Initial integration tests (static and dynamic) shall be done at the Rolling Stock factory and jointly performed by the test personnel of respective Contractors. Further main line integration tests will be required to be undertaken to ensure all train control functions between the OCC and the Train, which will be required to be done jointly by the Rolling Stock and Signalling & Train Control Contractor on site in Bangalore. The test certificate subsequently shall be issued jointly by the Rolling Stock, Signalling & Train Control Contractor. Integrated testing of each train with Signalling & Train Control system shall be done as under:
- (a) Signaling & Train Control Contractor shall develop ATC-RS joint test procedure for mainline testing. It shall be the responsibility of the Signaling/Train control Contractor and RS Contractor to jointly test each 6-car train set on mainline as per the ATC-RS joint procedure.
 - (b) Signaling/Train control Contractor during interface with RS Contractor shall develop a test procedure for obtaining the maximum energy saving in ATO mode over the entire section of E-W and N-S corridor including extensions.
- 11.1.10.26.5 The Rolling Stock Contractor shall provide test facilities for comprehensive static, dynamic, and interface tests between the Rolling Stock, Signalling systems at his premises. The Signalling & Train Control Contractor shall be responsible for the provision of special test equipment and instrumentation.
- 11.1.10.26.6 In the case of the ATO, the Integration test between the Rolling Stock and Signalling & Train Control Contractors shall include tests on the mainline to confirm the realization of the demanded acceleration and deceleration rate by the ATO under various conditions.
- 11.1.10.26.7 Should the need arise for modifications in the configuration of respective equipment or systems as a result of the Integration Test or otherwise, the scope of work and division of responsibility shall be jointly agreed amongst the Contractors and detailed procedure shall be developed. The Rolling Stock Contractor shall provide the requisite manpower to monitor and/or implement the modifications on the Rolling Stock for the work.
- 11.1.10.27 **EMC/EMI Interface**
- 11.1.10.27.1 With respect to electromagnetic interference, the Signalling and Train Control Contractor shall provide a list of frequencies and any other EMC/EMI requirements to the RS Contractor, to enable the Rolling Stock Contractor to avoid such frequencies in the design, and to provide devices to isolate the source of potential emissions wherever required.

- 11.1.10.27.2 The Rolling Stock and Signalling & Train Control Contractors shall ensure that the emission and immunity level of their respective equipment meet the requirements of EN50121-3-2.
- 11.1.10.27.3 The Rolling Stock Contractor shall ensure that the return current in the track at the specified frequencies does not exceed the value specified by the Signalling & Train Control Contractor.
- 11.1.10.27.4 The Contractors shall also jointly develop a test plan for verification of electromagnetic compatibility of traction and signalling system. The Contractors shall work together to assure that all electronic and electrical equipment on the Rolling Stock functions correctly without interference to the signalling system.
- 11.1.10.27.5 The cable layout of the signaling system in the cable ducts provided by the Rolling Stock Contractor shall be jointly agreed. The separation between signalling cables and power cables for 750V V DC, 415 V three phase AC, 230 V AC single phase, 110 V DC rating for traction and other power supplies shall be in accordance with accepted international practice and jointly agreed.
- 11.1.10.27.6 The cable ducts shall be earthed at notionally at every 2m and also at the ends and shall be in accordance with accepted international practices.

Scope of Interface

11.1.10.28 The S&TC and RS Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Item	S&TC Contractor	RS Contractor
1	On-board ATP equipment	To supply/deliver all the listed equipment under column "Item" to the Rolling Stock Contractor's Works as applicable.	To provide space in the vehicle design for fixing, carry out installation at the manufacturer's facility, by the Rolling Stock Contractor, under the supervision of the Signaling/Train Control Contractor as applicable.
2	On-board ATO equipment		
3	Antennae for ATP, ATS etc.		
4	Speed measuring sensors and speedometer / odometer		
5	ATC cab displays (train operators DMI) including special cables etc.	Furnish required voltage values and earthing requirements to Rolling Stock Contractor for his scope Shall provide the same	To provide the required voltages and earthing
6	Power supply and earthing for on-board ATP/ATO equipment		
7	Reading software tools for reading the ATC data from TCMS		
8	Logging of on-board information from ATP/ATO	<ul style="list-style-type: none"> The data logger shall facilitate identification of system level faults and segregate the faults on account of Rolling Stock or Signaling/Train Control System. Signaling/Train Control Contractor to co-ordinate with Rolling Stock Contractor for signal levels and protocols. 	Shall interface with S&TC Contractor to obtain software tools for reading ATC data recorded in TCMS Provide the recording and monitoring of signals and faults from ATC in TCMS
9	Interface between ATP/ATO with train braking and propulsion systems for automatic braking, acceleration and deceleration	ZVR and redundant EBR relays to be supplied by S&TC Contractor	
10	System master clock	S&TC Contractor to provide necessary inputs	
11	On-board next station information to passengers	Shall provide necessary signals on-board to Rolling Stock Contractor	Rolling Stock Contractor shall coordinate with the S&TC Contractor to agree on levels and protocols for interface signals RS Contractor to synchronize its clock with the system master clock. All subsystem clocks in RS shall be synchronized with the TCMS clock Shall provide for necessary hardware interface, display for on-board PA system inside the cars

SN	Item	S&TC Contractor	RS Contractor
12	Climatic requirements for on-board ATP/ATO equipment	Signaling/Train Control Contractor to specify at an early date, the total heat load wattage, and maximum permitted temperature.	Rolling Stock Contractor to provide conditioning air from the saloon to all relevant Signalling & Train Control installations to maintain a nominal temperature of 25°C. Conditioned air ventilation shall be provided by the Contractor for the console.
13	EMI/EMC interface between the RS and S&TC	Signaling/Train Control Contractor shall detail the EMI/EMC requirements to Rolling Stock at an early date and also jointly ensure the compliance with Rolling Stock.	Rolling Stock Contractor shall ensure the compliance of the requirements of Signaling/Train Control Contractor for on board ATP/ATO equipment.
14	Limitations of return current for proper functioning of ATC	Signaling/Train Contractor shall provide return current limits in already commissioned sections and new extensions applicable for new 6-car Rolling Stock.	Rolling Stock Contractor shall ensure the compliance of the requirements of Signaling/Train Control Contractor for ATC.
15	Train lines / communication architecture and media	Signaling/Train Control Contractor shall specify at an early date the requirement of Train lines / communication architecture and media.	Rolling Stock Contractor shall provide the necessary train lines/communication media as per agreed interface.
16	Rollback protection	Signaling/Train Control Contractor shall provide rollback protection system in ATC	Rolling Stock Contractor has to interface with Signaling/Train Control Contractor to achieve the rollback protection system
17	Wheel flange lubricator (WFL)	Lubrication will be activated at a specific location in a curve or just before the curve by TCMS based on ATC system. ATC bits for identification of curve location shall be provided by ATC to TCMS	Based on ATC bits, TCMS shall trigger WFL ON/OFF operation. ON/OFF status and WFL system healthy status will be available in TCMS

Notes:

- New 6-car trains which will be supplied for extensions of Line 1 and Line 2 will be with TCMS configuration. RS Contractor shall interface with Signalling & Train Control Contractor using existing communication protocol present in Phase-I train to achieve required functionality.
- Rolling Stock Contractor shall interface and provide new trains compatible with existing signalling system for the trains to be operated on the existing E-W and N-S lines with extensions. Each train set will be equipped with only one type of Signalling & Train Control system.

Rolling Stock Characteristics

1	6-Car consist formation	DMC-TC-MC-MC-TC-DMC
2	Average acceleration rate from 0 to 30 kmph	1 m/sec ² +/- 5%
3	Average service deceleration from 80 to 0 kmph	0.95 m/sec ² +/- 5% (braking characteristics will be implemented in 6-car train sets where constant Torque zone in the Braking shall be from 65 kmph to 5 kmph)

4	Minimum average emergency deceleration	1.3 m/sec ²
5	Maximum Jerk	0.7 ± 0.05 m/sec ³
6	*Service Brake Response Time	< 2 sec
7	*Emergency Brake Response Time	< 1.5 sec
8	*Service and Emergency Brake Release Time	< 2.5 sec
9	Guaranteed Emergency Brake rate	For RS Phase-I project, Guaranteed Emergency brake rate considered as under: <ul style="list-style-type: none"> • 0.79 m/s² on tunnel sections • 0.74 m/s² on elevated and at grade section Signaling/Train control Contractor shall get further confirmation from RS Contractor during design phase. RS Contractor shall provide/ confirm the requested values.
10	Resistance to motion (formula, curve, starting resistance)	$R = 14.01 + 0.264 V + 0.00191V^2$ (N/ton) for At-grade and Elevated corridors $R = 21.96 + 0.4222V + 0.00876V^2$ (N/ton) for Underground corridor Where R is Train Resistance (N/ton), V is Train Speed Km/h
11	Maximum Vehicle Overhang (i.e., length between the face of coupler extremity and the first axle of the bogie) (rounded 10mm)	2570 mm
12	Maximum wheel diameter	860 mm
13	Minimum wheel diameter	780 mm
14	Maximum train design speed	90 kmph
15	Maximum train service speed	80 kmph
16	Door opening and closing times	Opening time is 2.5 s (± 0.5s) Closing time is 2.5 s (± 0.5s)
17	Tare weight Cars	222.378 tonnes for 6-car
18	No of axles per Car	4
19	Presence of non-service brake and non-powered axles	All DMC and MC car axles are powered while those of TC cars are non-powered. All axles are friction braked.
20	Axle Load	15 tonnes
21	Train length – 3 Car Train	65.2 m
22	Train length – 6 Car Train	130.3 m

Notes:

- (1) All of the data in the above table are notional and should be confirmed between the Contractors during design phase.
- (2) For Line1 and Line 2, Detailed Interface Documents have already been issued, which shall be used as baseline documents.
- (3) For the items marked *the timings are for a brake application from full release to 90% of full brake cylinder pressure, and for brake release from full brake cylinder pressure to 10% as per EN 13452-1.
- (4) RS characteristics are provided for existing 6 car trainsets. However, it shall be the responsibility of the Signalling & Train Control Contractor to interface with RS Contractor to confirm these values during design phase. It shall be the responsibility of the RS Contractor to provide/confirm the values as requested by Signalling & Train Control Contractor.

- (5) RS characteristics for new 6 car trains shall be finalized during design phase. However, it shall be the responsibility of the Signalling & Train Control Contractor to interface with RS Contractor to obtain the required values during design phase. It shall be the responsibility of the RS Contractor to provide the values as requested by Signalling & Train Control Contractor.

11.1.11 INTERFACES BETWEEN ROLLING STOCK AND SIGNALLING & TRAIN CONTROL CONTRACTORS (CBTC SIGNALLING SYSTEM)

11.1.1.1 Definitions and Scope

11.1.11.1 This Appendix describes the interface requirements between Rolling Stock Contractor and Signalling & Train Control Contractor.

11.1.11.2 The details of these Contracts and Contractors shall be made available during the execution of the Contract.

11.1.11.3 The Signalling & Train Control and Rolling Stock Contractors shall ensure that all requirements of the Specification pertaining to interfaces are comprehensively satisfied.

11.1.11.4 The requirements specified herein are by no means exhaustive and it remains the responsibility of the Signalling & Train Control and Rolling Stock Contractors to develop and execute an interface plan during execution of the work to ensure that:

- (i) All interface issues between the different Contracts are satisfactorily resolved
- (ii) Supply, installation and testing of equipment and software are fully coordinated
- (iii) All equipment supplied in the Contracts are fully compatible with each other.
- (iv) UTO mode of operation is achieved with all inherent features.

11.1.11.5 The Automatic Train Protection (ATP) system shall issue the braking commands to the Rolling Stock when safety limits are exceeded or when over-speed is detected. The removal of traction power and the correct application of brakes shall be the responsibility of Rolling Stock Contractor. The ATP system shall be responsible for monitoring of speed and the issuing of braking commands when safety speed limits are exceeded.

11.1.11.6 Parking brakes shall be provided by the Rolling Stock Contractor. The parking brakes shall be capable of holding a fully loaded stationary train on a 4% gradient under all track conditions, indefinitely.

11.1.11.7 There shall be two stage commissioning. In the first stage, the train operation shall be commissioned in GoA-2 mode and in second stage GoA-4 mode of operation.

11.1.1.2 Interface Management

11.1.1.2.1 Each contractor shall establish a structured process to integrate with other systems to ensure safe, reliable, and efficient operations under both normal and degraded conditions to the satisfaction of the Engineer.

11.1.1.2.2 Each contractor shall ensure that the equipment supplied under this Contract are properly interfaced and integrated with other systems in Bangalore Metro.

11.1.1.2.3 Each contractor shall appoint competent and experienced person (Interface Manager), with no fewer than 5 years of similar Metro railway project experience who shall be the single point of contact for all interface design and testing works with the interfacing contractors and the Engineer.

- i. Full time mobilization of 'Interface Manager (IM)' at site shall be done by RS as well as Signalling Contractor within three (3) months of the Effective Date. Non-mobilization of the 'Interface Manager (IM)' within the stipulated three months would attract penalty (to be solely finalized by the Engineer) for delay of each month or part thereof. The penalty amount shall include the consequential loss on account of non-availability of an approved and experienced 'Interface Manager (IM)'.
 - ii. All Interface Meetings, unless specifically approved by the Engineer, shall be held at site and the Engineer shall be given sufficient notice to attend the meeting.
- 11.11.2.4 Each contractor shall be responsible for interface identification, establishment, construction, and testing works either in the capacity as the lead contractor or participating contractor.
- 11.11.2.5 Signalling & Train Control Contractor shall be the Lead Contractor. The Signalling & Train Control Contractor will be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors all the required interfaces and interface design documents and interface progress reports for submission to the Engineer for acceptance. The Signalling & Train Control Contractor will also prepare and issue all interface meeting minutes after incorporating RS Contractor's comments within 3 days of the meeting and provide bi-weekly interface progress reports to all the participating contractors for information.
- 11.11.2.6 Later, forwarding of issued minutes of meeting and bi-weekly interface progress reports to respective Engineers shall be responsibility of concerned Contractors.
- 11.11.2.7 All the participating contractors shall ensure that copy of the Interface design documents submitted to the Engineer of the Signalling & Train Control Contractor shall also be submitted to their respective Engineer required to participate in the Interface Meetings.
- 11.11.2.8 Rolling Stock, Communication, PSD/PSG and TVS Contractors will be the participating contractors. The Participating Contractor shall collaborate fully with the Signalling & Train Control Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.
- 11.11.2.9 The costs for all interface design and testing works shall be deemed to be included in the Contract sum regardless of the actual extent of effort required or expended by the Contractor.
- 11.11.2.10 The Contractors shall be fully responsible for the management and control of his subcontractors in relation to all interfacing activities carried out under the Contract.
- 11.11.2.11 The Signalling & Train Control Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of the trains during the DLP of Signalling and Train control Contract. The Rolling Stock Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of trains till completion of Signalling defect liability period. It shall also be noted that changes in the interface specifications such as key alarms, remote commands, interface signals and GUI specifications are to be expected throughout the project execution stage and shall extend up to 6 months after commencement of UTO operation based on operational requirements.

- 11.11.2.12 Rolling Stock Contractor shall be responsible for development of the GUI (including hardware) for the RS controller (RSC) in the OCC (Operation Control Centre)/BCC (Backup Control Centre). Any other GUI(s) in OCC/BCC shall not be the scope of RS Contractor. Total number of the distinctively different screens with live buttons may be around ten. The exact number shall be confirmed in the design stage.
- 11.11.2.13 Signalling & Train Control Contractor shall ensure suitable connectivity between the workstations of the Traffic Controller, RS Controller, CCTV, and others as finalized during interface design.
- 11.11.2.14 Signalling & Train Control Contractor shall provide server for CCTV in the OCC/BCC. All the requirements of buffering to be done on the train for live streaming of video shall be the responsibility of RS Contractor.
- 11.11.2.15 Signalling & Train Control Contractor shall be responsible for enabling and implementing any addition / deletion of the alarms from the trains to OCC/BCC and remote commands from the OCC/BCC to train throughout the project execution stage including up to 6 months after commencement of UTO operation, as advised by the RS Contractor/Engineer. Rolling Stock Contractor shall provide necessary support required to implement the same. Separate set of alarms and commands may be required to be reported/executed from the Traffic controller and the RSC workstations. RSC workstation shall be the responsibility of RS Contractor.
- 11.11.2.16 Adequate number of workstations as decided during the Interface Finalization shall be provided in OCC/BCC by the Signalling & Train Control Contractor for passenger communication with OCC/BCC on invoking of PEA (Passenger Emergency Alarm).
- 11.11.2.17 In the event of invoking of the PEA, automatic pop up of image from the relevant cameras shall be ensured in the OCC/BCC on the LVS, screens of traffic controller and RSC. RS Contractor shall interface with Signalling & Train Control Contractor for invoking of CCTV images on RSC workstation.
- 11.11.2.18 Signalling & Train Control Contractor shall be responsible for free supply of cables, duly harnessed for connection of the On-board signal equipment. RS Contractor shall be responsible for providing the cables for the train lines and/or Ethernet links required by the Signalling & Train Control Contractor. The Rolling Stock Contractor shall ensure the availability of adequate no. of train lines/ethernet considering the requirement of Signalling & Train Control Contractor, which shall be discussed and finalized during interface. RS Contractor shall ensure that adequate number of spare train lines (minimum 10% for each type) will be available for future use.
- 11.11.2.19 Signalling & Train Control Contractor shall certify relevant connections, cables to on-board Signalling equipment after their assembling in first (prototype) & subsequent trains at RS Contractor's premises.
- 11.11.2.20 Signalling & Train Control Contractor shall be responsible for providing suitable communication link for live streaming via CCTV network from Train to OCC/BCC and for live transmission of the advertisements or other data via CCTV network from OCC/BCC to Train. The live video stream transmitted from the train to the OCC/BCC shall be suitably buffered and to be streamed from OCC/BCC CCTV server for its onward multicast transmission to other terminals/networks and display on all relevant terminal/screens using Video Management System (VMS). This buffering arrangement in OCC/BCC via CCTV server including VMS and display large video walls shall be responsibility of Signalling & Train Control

Contractor. For live video stream from OCC/BCC to train, the buffering on the train shall be responsibility of RS Contractor. The Rolling Stock Contractor shall provide Live Video Players with buffering capability on the Train. The RS Contractor shall also provide the advertisement and live video players in hot standby pair per train. The RS Contractor shall also provide redundant suitable arrangement (video controller/player/servers) in OCC/BCC for transmission of live video contents and stored video contents to be played in the train.

- 11.11.2.21 The contractors shall ensure that all the requirements of the latest Metro Railway General Rules are duly met by incorporating appropriate alarms, remote commands, and other features.
- 11.11.2.22 Signalling & Train Control Contractor in close coordination with the RS Contractor shall ensure that the ATO/UTO modes of operation designed are optimized for least energy consumption.
- 11.11.2.23 It is expected that complete duplication of the TCMS VDU screen with live buttons for executions the requisite commands shall be available on demand in the RSC- GUI.
- 11.11.2.24 Not Used
- 11.11.2.25 Both Signalling & Train Control as well as RS Contractor shall ensure that complete and detailed log of the signals exchanged between ATC and TCMS shall be retrievable on demand for diagnostics.
- 11.11.2.26 Not Used
- 11.11.2.27 Signalling & Train Control Contractor shall be responsible for slow speed movement on the Automatic Wash Plant (AWP). Interface will be required to be done with the AWP supplier for ATO/UTO modes. RS Contractor shall provide wash mode facility for other manual modes like ATP/RM/ROS/Cut-out.
- 11.11.2.28 Emergency brake application validation at slow speed (less than or equal to 25kmph) shall be achieved as a part of the wake-up procedure as finalized by the Signalling & Train Control Contractor. The speed at which brake test has to be carried out shall be finalized during design phase based on the available length of stabling line.
- 11.11.2.29 Signalling & Train Control Contractor shall ensure that in the event of secondary suspension deflated condition detection or otherwise, the maximum speed shall not exceed the stipulated speed under such condition as advised by the RS Contractor. This information shall be provided by RS to Signalling & Train Control Contractor on board in a safe manner.
- 11.11.2.30 Signalling & Train Control Contractor shall provide location information to the RS Contractor. RS Contractor shall use the same for different distance-based algorithms provided in the RS like for station announcements, wheel flange lubrication, etc.
- 11.11.2.31 Signalling & Train Control Contractor to ensure that the maximum speed shall be regulated as advised by the RS Contractor on account of following:
 - i) Secondary suspension deflated condition detection

- ii) Bogie brake failure/isolation (In both brakes fail to apply and fail to release cases)
- iii) Axle block detection
- iv) Isolation/Cutout of Electro dynamic braking
- v) This information shall be provided by RS to Signalling & Train Control Contractor on board in a safe manner.

11.11.3 Train Operating Modes

11.11.3.1 General System Descriptions

- 11.11.3.1.1 The train-borne Automatic Train Control (ATC) system will consist of Unattended Train Operation (UTO), Automatic Train Operation (ATO) system and Automatic Train Protection (ATP).
- 11.11.3.1.2 The Rolling Stock required shall be fitted with ATP/ATO/UTO system. The UTO system shall conform to Grade of Automation 4 (GoA4) as defined in IEC 62290-12014 or latest.
- 11.11.3.1.3 The Automatic Train Control (ATC) System shall be supplied by the Signalling & Train Control Contractor, who shall be required to liaise closely with the Rolling Stock Contractor, in regard to the installation, testing and commissioning of the Signalling & Train Control equipment.
- 11.11.3.1.4 **Unattended Train Operation (UTO Mode)**
This mode consists of full driverless unmanned operation and shall be the default mode at stage-2 of commissioning unless exceptional circumstances occur. This mode shall be available everywhere on the line and the depot except for the workshop lines. Details shall be finalized during interface and design finalization.
- 11.11.3.2 **ATO Mode**
 - 11.11.3.2.1 The on-board equipment shall provide for Automatic Train Operation (ATO). In this mode, the train's speed, motoring, coasting and braking within the parameters dictated by the ATP system shall be performed by the on-board equipment without the train operator's intervention. The train shall operate in ATO mode when the mode selector is at ATO mode and ATO Start button is activated. This operation shall include:
 - (i) Automatic operation of trains between stations including auto turn backs.
 - (ii) The ATO system shall provide control for acceleration, deceleration and coasting of trains in such a manner that the specified schedule speed is achieved with minimum energy consumption. ATO shall also provide "All-Out Mode" of train operation to make up time loss to the extent possible by reducing the coasting period, in case train is not running in accordance with Time-Table.
 - (iii) Control of acceleration & deceleration of Train including coasting.
 - (iv) Automatic stopping of trains at platforms within a tolerance of ± 250 mm for 99.98% of station stops.
 - (v) This stopping accuracy must be obtained under all train loading conditions and taking into account the possible different variations in Rolling Stock characteristics.
 - (vi) Automatic opening of doors on the appropriate platform side(s) when the train is berthed.
 - (vii) Prevent the train from starting if train doors are detected "not closed and locked".
 - (viii) Receipt and implementation of control to skip one or more stations.

- (ix) CBTC system shall allow a train to enter a station platform only if the preceding train has a movement authority that shall allow it to fully leave the platform area and it has begun to move out of the station (i.e., within ATP constraints, train movement shall be controlled to minimize the likelihood of the train coming to a stop when only partially within the station platform limits). The trains under ATO operation shall always remain under ATP protection. Transfer from ATP to ATO mode shall only be possible at standstill at a designated stopping point. However, transfer from ATO to ATP mode shall be possible at any time at standstill. The details shall be finalized during design stage.
- (x) It shall be possible for train operator to close the doors and start the train in ATO mode even before dwell time at less crowded stations.

11.11.3.2.2 The automatic train operation unit is permanently supplied as soon as the train is ready for operation. It must be in normal operating status at power up. Transmission of orders to train equipment is only possible in ATO mode.

11.11.3.2.3 When the ATC system detects the stop short outside the station stopping window and the Trains is within station, it shall initiate Trains inching (forward) to bring the Trains to stop within station stopping window. Detailed design of inching operation shall be submitted for Engineer's review during design phase.

11.11.3.2.4 Powering/Braking command and demand:

- (i) The powering and brake commands shall be implemented through hardwired interface. However, powering and braking demands shall be implemented through TCMS interface. In case of UTO/ATO operation, powering/braking demands shall be implemented with safety data transmission protocol through ethernet interface between ATO/ATC and TCMS.
- (ii) Redundant communication shall be available between TCMS & ATO/ATC (Dual Homing) to implement the above functionality. TCMS shall also provide redundant communication network to transmit the powering and braking demand from ATO/ATC to traction inverters and BECU.
- (iii) In case of failure of TCMS or failure of data transmission between ATO/ATC and TCMS, powering and brake demand shall be implemented through hardwired circuits under the supervision of ATC.

Details shall be discussed and finalized during design phase.

11.11.3.2.5 Door control

- (i) The doors shall be arranged for cab control operation. The control circuit shall be hardwired so that all the doors on either side may be operated automatically by either ATO command or manually with respect to designated platform side.
- (ii) The door control push buttons shall be illuminated with distinct colour lights. The details and schematic shall be provided for review of the Engineer.
- (iii) The opening and closing of doors shall only be possible from an operative cab. The door controls shall be located on train operator's console.

- (iv) The door control panels shall be located conveniently for operation of the doors on that side of the train. The control devices located on each side of the cab shall only operate the doors on that side of the consist.
- (v) All door control panels in the train operator's cab shall have an identical layout and shall be physically interchangeable.
- (vi) A Door Mode switch shall be provided in the cab. In ATO mode, the automatic door open command may be overridden by operating this switch. Operation of this switch shall be monitored by TCMS.
- (vii) The ATC system shall ensure that no movement of the Trains in ATP/ATO/ UTO mode is possible until all Trains doors and PSD/PSG are closed (in case PSD/PSG is provided).
- (viii) The ATC system shall also ensure that in ATP/ATO/UTO mode, if the PSD/PSG is opened, no Trains shall be allowed to enter the platform; approaching Trains shall stop immediately if it is already within braking distance from the platform; the leaving Trains shall stop immediately if it is within a preset length from the platform; the berthing Trains shall not be allowed to leave. When the interlock override switch is operated, Trains are allowed to operate in all modes into and out of the platform. This switch shall be supplied by the PSD/PSG Contractor and is a one-shot operation device (in case PSD/PSG is provided).

11.11.3.2.6 Door opening authorization in degraded operation

- i) In case of unavailability/failure of door authorization signal from ATP system, adequate safeguards shall be provided and also incorporated in control circuit to minimize the probability of error of opening of doors on wrong side (other than platform side) during commercial / revenue service.
- ii) In this case, the opening can be controlled by the train operator operating a sealed Safety Cut-out Switch (SCS) operation and the right opening button or a left opening button placed on the desk.
- iii) This mode may be also used:
 - a) On the stabling/de-stabling secondary track.
 - b) On the main track without platform (evacuation of passengers in inter station).
 - c) At the platform (in case of failure of automatic operation).
- iv) The opening of the doors shall only possible when the Train speed is Zero.

11.11.3.3 Coded Manual (ATP) Mode

11.11.3.3.1 The on-board ATC equipment shall provide Automatic Train Protection (ATP) on all lines/ sections. In this mode, the control of the train speed and braking within the parameters dictated by the ATP system shall be performed by the train operator.

11.11.3.3.2 The Coded Manual (ATP) mode shall include:

- i) Identification and enforcement of maximum safe speed at which the train may operate, as deduced from the most restricting ATP condition.
- ii) Identification and display of actual speed, target speed and target distance.
- iii) Identification and audible and visual warning when train is operating at a speed higher than the target speed. The equipment to provide audible and visible warnings shall be provided by respective Signalling & Train Control Contractor.

- iv) If the actual speed exceeds the target speed, an audible and visual warning shall be given to the Train Operator. The Train Operator shall be given at least 2 seconds before the intervention of the full-service brake. If the speed is not reduced by the Train Operator and actual speed exceeds the target speed after 2 seconds, full-service brake shall be applied up to a predefined speed exceeding the target speed (to be decided during the design phase). If the full-service brake fails or is not adequate and the speed exceeds the predefined speed, then ATP shall apply the emergency brake. The full-service brake intervention and emergency brake intervention must be recorded. Once applied by the ATP system, the emergency brakes shall not be able to be released until the train reaches a complete stop. Each such operation will be recorded on the train-borne data log. Details shall be submitted for Engineer's review during design phase.
- v) Identifying the platform side of the train with the train berthed at a station. The system shall then enable the doors to be opened on that side upon completion of ATC changeover from rear to front, if any; and
- vi) Receipt of a door closed signal indicating that all doors are closed and locked before the train may start. Loss of this signal shall cause the ATP system to initiate an Emergency brake application.

11.11.3.4 Restricted Manual Mode (RM) and Run On Sight Mode (ROS)

- 11.11.3.4.1 In RM mode, principally for use in depots and on mainline in case of failure of the wayside Signalling. The maximum train speed shall be controlled by the on-board ATP. This limit may be configurable to a speed determined to be safe for unsupervised driving between 15kmph and 25kmph. This mode shall be available only when the on-board ATP equipment is operational. The RM mode shall be operational when selected by the Train Operator.
- 11.11.3.4.2 The train operator shall be given a warning, both audio and visual when the speed is above RM threshold but below 25 kmph.
- 11.11.3.4.3 In Restricted Manual Mode, the train operator shall be able to control Train doors when the Train is stopped within the station stopping limits.
- 11.11.3.4.4 In ROS mode of operation, the train operator Runs on Sight. ROS mode shall be selected by a ROS button/ Key. ATP authorizes ROS request. In ROS mode, the train speed shall be controlled by the on-board ATP as in the case of RM mode. ATP shall give cab signal indications as soon as the train reaches a track position where normal running can be resumed.
- 11.11.3.4.5 The ROS driving mode will be unselected and will automatically switch from ROS to ATP with no brake application.

11.11.3.5 Restricted Manual Reverse (RMR) Mode

Reverse operation shall be possible by bringing the Mode Selector in RMR position with ATP protection. It shall be possible to run in reverse direction under ATP protection on mainline.

The maximum permissible speed of the train shall not exceed 10kmph in reverse mode for a predefined distance. This predefined distance shall be designed by the Contractor and submitted to the Engineer for Approval.

11.11.3.6 Not Used

11.11.3.7 Manual Cutout (or Bypass) Mode

- i) By-pass Mode shall be provided for use in the event of failure of the ATP system. In this mode, the train speed shall be controlled entirely by the train operator, to a limit adjustable between 15 kmph and 25 kmph. RS Contractor shall provide equipment and means to ensure that the maximum train speed remains within the above limit when the Cut-out Mode is in effect, under all circumstances. In case speed of the train exceeds 25kmph, 70% FSB shall be applied by RS Contractor.
- ii) The ATP By-pass Mode shall be initiated by the train operator operating a sealed Safety Cut-out Switch (SCS) and simultaneously breaking its seal. The operation shall be recorded by the on-board digital counter and TCMS. The SCS shall be provided by RS Contractor. The on-board digital counter shall be provided by the Signalling & Train Control Contractor. In this mode the train doors shall only be enabled and controlled manually.
- iii) The availability of power supply to the ATC system during this mode will be decided during the design finalization.

11.11.3.8 Washing and coupling mode

In Wash & Coupling mode, the speed is between 3 kmph to 5 kmph to prevent any damages of the automatic washing machine equipment and for safety reasons. Wash/Coupling mode will be selected through TCMS with SCS switch in Normal position with Mode selector in Forward position.

11.11.3.9 Unattended Trains Operation (UTO)

- 11.11.3.9.1 UTO operation shall be compliant to EN 62290-1 to 3, IEC 62267:2009 or latest and IEEE1474-1 to 3-2008 or latest.
- 11.11.3.9.2 The Trains shall operate in Unattended Trains Operation (UTO) mode when the mode selector is at "OFF" position and the UTO button activate.
- 11.11.3.9.3 Information of the operation of the equipment shall be transmitted to the OCC/BCC via the Communication system or Signalling & Train Control system. Sufficient information shall be transmitted to enable the OCC/BCC to determine the status of the equipment, sub- systems, and systems of the Trains and to issue the required control commands to the Trains via the radio communication system or Signalling & Train Control system to control the equipment or reset any equipment to meet the safety and reliability requirements specified in this specification.
- 11.11.3.9.4 All radio communication equipment and Signalling equipment of the Trains shall be maintained in active status, ready to receive or transmit any data to and from the OCC/BCC.
- 11.11.3.9.5 All equipment shall be provided with self-diagnostics function and the health status shall be transmitted to the OCC/BCC via the Communication system or Signalling & Train Control system.
- 11.11.3.9.6 Under UTO mode, the train departure, train running, and train stopping shall be controlled by Signalling & Train Control system.
- 11.11.3.9.7 Under UTO mode, the Trains shall achieve a station stopping accuracy of $\pm 250\text{mm}$ with 99.98% accuracy.

- 11.11.3.9.8 To enable the OCC/BCC to handle “Undershoot or Overshoot” situations at station’s normal stopping point, the OCC/BCC shall be able to command the Trains to perform inching movement via the Signalling & Train Control system.
- 11.11.3.9.9 The trains shall be capable of travelling between 3 kmph to 5 kmph (under Signalling control) to enable exterior cleaning at the Automatic Wash Plant. The Contractor shall submit the details during design phase.
- 11.11.3.9.10 Automatic opening of doors on the appropriate platform side(s) when the train is berthed. When the dwell time has elapsed, the Trains doors shall be closed automatically with PA and chimes prior to the door close operation.
- 11.11.3.9.11 Under UTO operation, it shall be possible for the Signalling & Train Control system or the OCC/BCC to remotely set the Trains to operate in any of the following operation modes:
- i) Sleep Mode
 - The Trains shall enter shutdown mode.
 - Equipment required enabling the Trains to receive commands from the Signalling & Train Control system and radio system shall remain live.
 - ii) Wake Up Mode
 - All systems shall be initialized and a self-check to be carried out to confirm the health status.
 - The Trains shall be put in a state ready for service.
 - The OCC/BCC and the Signalling & Train Control system shall be notified when the Trains is ready for service.
- In the event the Trains fails to complete the shutdown/initialization process, sufficient details of the failure shall be transmitted to the OCC/BCC to enable the determination of appropriate actions to be taken.

11.11.3.10 **ATB (Automatic Turn Back) Mode**

The ATO mode shall include Automatic Turn back at the terminal stations including intermediate turn back stations. The Automatic turn back facility will be without driver and shall be provided at terminal stations at

- a) Platform of the terminal station
- b) Turn back track at rear of the terminal station and
- c) Platform of intermediate turn back station.

The details of ATB function will be discussed and finalized during design stage. Rolling Stock Contractor has to interface with Signalling & Train Control Contractor to design ATB Feature and submit the proposal for Engineer’s review during design phase.

11.11.3.11 **Fall-back mode**

The ATP mode shall include a fallback mode if the ATP track side equipment or the radio infrastructure fails. In such case, the system shall use the axle-counter to detect the position of the trains, set protection area before and after the train and command the train operation with track side Signalling. The driver manually drives the train based on the display of the track side signal and cab signal.

11.11.3.12 Identification: Train Operating Mode, Train Description and Next Station Information

- i) The Signaling & Train Control Contractor shall provide a four-digit digital Train Identification Number (Train ID) to the Rolling Stock Contractor. The first two digits shall identify the destination while the second two digits shall be the service identifier. The destination codes shall signify unique routes. The destination code shall also be provided for different lines in a station so that this code can be utilized by other sub-systems for their respective purpose. The Rolling Stock Contractor shall accordingly use the relevant information such as names of intermediate stations, stopping pattern, station stop door opening side information, skipping station information, keep door close information, train going to depot information etc. for operation of on-train systems.
- ii) Train ID shall be allocated to train when it enters the service and shall be maintained until it finishes its service. It shall be possible by the Employer to amend and / or modify the Train ID, subsequently, to suit the operational requirements. The Signalling & Train Control and Rolling Stock Contractors shall provide necessary equipment and means for the same to be defined during the detailed design stage. Rolling Stock contractor shall provide suitable arrangement for train operator to view the Train ID on TCMS and also Signalling & Train Control contractor shall provide suitable arrangement for train operator to view the Train ID on DMI.
- iii) The Rolling Stock and the Signalling & Train Control Contractors shall exchange information identifying the effective mode, the active or non-active status of each cab, the door status etc. The inputs shall be categorized as vital and non-vital. The levels and form of these inputs shall be Coordinated between the two Contractors.
- iv) The Rolling Stock Contractor shall provide necessary inputs to the Signalling & Train Control Contractor identifying the required mode and status of active cab etc. RS Contractor shall provide rake ID and other relevant information as mutually decided with Signalling & Train Control Contractor, the levels and form of these inputs shall be Coordinated between the two Contractors.
- v) The Rolling Stock Contractor shall log each time the mode is changed using the on-board TCMS equipment.
- vi) In By-pass or Cut-out Mode, an external indication light shall flash or occult. Details shall be finalized during design stage.
- vii) The Signalling & Train Control Contractor shall provide the necessary input signals (next station information code, platform side information, triggering signal, Departure bits, arrival bits, Destination bits etc.) to Rolling Stock for displaying and making next station announcements to passengers on-board. The Rolling Stock Contractor shall provide the necessary hardware. Levels and protocols shall be agreed between the contractors.
- viii) For UTO/ATO operation, the necessary train command digital inputs signals shall be provided by the Signalling & Train Control Contractor. The ATP/ATO/UTO initiated signal demands shall be redundant. The redundancy shall also be provided on TCMS side by RS Contractor. The form of these inputs shall be coordinated between RS and Signalling & Train Control Contractors.

11.11.4 Interface Requirements between S&TC and RS Contractors

11.11.4.1 General

- 11.11.4.1.1 Signalling and Train Control Contractor shall provide the Rolling Stock Contractor with the final list of equipment to be provided on the Rolling Stock. The sizes and weights of the UTO/ATO/ATP on-board cab equipment and antennae etc. to be mounted on the Rolling Stock shall also be provided, as applicable. The location of the on-board cab equipment shall be mutually agreed between Signalling & Train Control and Rolling Stock Contractors so as to optimize seating & standing space duly considering maintainability and easy accessibility. However, the on-board ATC equipment shall not be placed in the under frame on account of maintainability issues.
- 11.11.4.1.2 The Signalling and Train Control Contractor shall deliver to the Rolling Stock Contractor's factories, all train-borne ATC equipment, as applicable, and data to enable fitting and testing. Connector fixing and cable harnessing shall be done by RS contractor under the supervision of Signalling & Train control Contractor.
- 11.11.4.1.3 The Signalling & Train Control Contractor shall supply at Rolling Stock Contractor's factories pre-wired equipment racks with appropriate connectors for all wiring terminating inside ATC, including wiring between ATC racks. The Signalling & Train Control Contractor, with the details provided by Rolling Stock Contractor shall ensure that the exterior finish and colours of the respective equipment suitably harmonize with that of the Train interior and the vicinity.
- 11.11.4.1.4 For Compatibility, the Rolling Stock and train detection system (axle counters), shall conform to EN 50238.
- 11.11.4.1.5 Interfacing wiring for each module provided by Signalling & Train Control Contractor including the interfacing wiring between Signalling & Train Control equipment shall terminate in a quick disconnect robust plug connector suitable for traction applications, with direct cable connection as far as possible. All cable connectors shall be identified within the cubicle using robust cable markers with distinctive colors for identification of e.g. safety function cables.
- 11.11.4.1.6 For all relay contact interfaces Signalling & Train Control Contractor shall provide auto-contact jam detection and contact bounce elimination function to ensure proper operation of the system. Relays for safety functions shall comply with the appropriate internationally accepted standard specification.
- 11.11.4.1.7 Signalling & Train Control Contractor shall provide Rolling Stock Contractor with the number of wires and/or Ethernet connections required between cars of a married pair and between married pairs to transmit signals from one end of the rake to the other end through electrical jumper. Provisions of redundancy and spares shall be catered by contractor for train lines and/or Ethernet connections.
- 11.11.4.1.8 Rolling Stock Contractor shall provide necessary video ports, power points and space onboard the train for monitoring video camera installed in the saloon area from OCC/BCC. For this necessary liaison shall be made with Signalling & Train Control Contractor.
- 11.11.4.1.9 Vehicle control circuits shall be developed by the Rolling Stock Contractor. During the design stage, all the vehicle control circuits incorporating the identified interfaces shall be provided to the Signalling & Train Control Contractor, as applicable. Signalling & Train Control Contractor shall provide specific observations on these circuits to the Rolling Stock Contractor. The Rolling Stock Contractor shall suitably incorporate these observations in the design.
- 11.11.4.1.10 Screened cables for train borne Signalling & Train Control equipment shall be properly terminated so as to ensure that no return loops are formed to cause electrical noise.

- 11.11.4.1.11 Not used
- 11.11.4.1.12 Both Signalling & Train Control and Rolling Stock Contractors to ensure that all signal received from Signalling & Train Control equipment and signals sent to Signalling & Train Control shall be recorded and shall be available for retrieval for analysis / record. All signals exchanged between Rolling Stock and Signalling & Train Control shall be monitored through TCMS. Signalling & Train Control Contractor shall interface with Rolling Stock Contractor to finalized the necessary format which their data will be captured by TCMS and shall also provide necessary reading tools to read this data from TCMS.
- 11.11.4.1.13 Rolling Stock Contractor shall ensure that all doors related and other safety / train control related signals including brakes, position of safety cut out switch, direction related relays, suspensions, obstruction on track etc. are communicated to the Signalling & Train Control Contractor. Safety related signal from Rolling Stock side shall be communicated to Signalling & Train Control Contractor as per the requirement for ATP/ATO/UTO mode of operation.
- 11.11.4.1.14 Signalling & Train Control Contractor shall define as a part of interface, the signals that will be provided by Signalling & Train Control train borne equipment to Rolling Stock Contractor for incorporating in Rolling Stock design.
- 11.11.4.1.15 Provision of “Jog mode” operation (for aligning train in case of undershoot/ overshoot of Normal stopping point within a limit) and “creep mode” operation (for moving the train under protection of ATP in case of UTO system failure) shall be addressed in the interface. Details shall be discussed and finalized during the design phase.
- 11.11.4.1.16 The Rolling Stock Contractor and Signalling & Train Control Contractor will jointly finalize a list of actionable command and responses for UTO (GoA-4) mode of operation which shall be available at Central Automatic Train Supervision (CATS) system at OCC/BCC as well as Local workstation at Station Control Room (SCR). The two contractors shall also finalize the list of alarms and events for Rolling Stock monitoring and troubleshooting which shall be displayed on the Rolling Stock controller monitor of CATS system at OCC/BCC as well as on other suitable terminals in depot and on the mainline. The information given to the OCC/BCC shall be clear and concise on nature of the fault. The OCC/BCC shall only be informed of failures that could result in the train being unfit for passenger service. Superfluous and misleading information shall not be displayed.
- 11.11.4.1.17 The key alarms, which are related to the events of operation, safety etc. and critical/serious in nature shall be displayed to both Traffic Controller as well to Rolling Stock Controller. All other alarms and events shall be displayed to Rolling Stock Controller.
- 11.11.4.1.18 The list of alarms, events and remote-control commands shall be proposed by Rolling Stock Contractor and approved by the Engineer. The implementation of alarms, events and remote-control commands shall be ensured by both the Contractors. The packet size should have margin to accommodate additional requirement for future.
- 11.11.4.1.19 The Engineer shall be able to add/delete/modify the alarms, event and remote command up to 6 months after commencement of UTO operation. Necessary training and hands-on shall be provided during execution of project.

- 11.11.4.1.20 Rolling Stock Contractor shall propose a user-friendly Graphical User Interface (OCC GUI for RS Controller) in both OCC & BCC in the form of a conceptual schematic/wireframe that shall include page layouts, arrangement of the GUI's content, interface and navigational elements, and a description of how they work together. The features of OCC GUI for Rolling Stock Controller shall be as under:
- a) The GUI shall have the capability to monitor the information of all trains within the network. The GUI shall employ different colors for highlighting different status of trains. The status of various subsystems, MCBs, Relays & Switches, Train Lines shall be displayed on GUI, and it shall be possible to acknowledge faulty trains immediately. It shall be possible to identify cause of Events/Alarms on GUI.
 - b) The GUI shall make available both current faults and historical fault records with provision of sorting and filtering the list.
 - c) There shall also be a provision to request on-board TCMS VDU screen on demand for display on RS controller screen with automatic refresh periodically not more than 1 second, with navigation feature and actionable button.
 - d) A user-friendly Troubleshooting Directory (TSD) shall also be made available in the GUI.
 - e) The GUI shall also make available remote-control commands via clickable screen button elements that shall be visibly different from non-clickable icons/shapes. It shall be possible to distinguish which remote control command is active/inactive. Remote control commands from OCC GUI for RS Controller shall be additional to the commands from ATS.
 - f) The screen elements shall be dynamic dropdown menus to make optimum use of screen area.
- Transfer and display of OCC GUI from RS Controller workstation to LVS shall be responsibility of Signalling & Train Control Contractor for which Rolling Stock and Signalling & Train Control Contractors shall interface.
- 11.11.4.1.21 Train Operation Data (TOD) shall contain train status data and faults/alarms/information etc. to be displayed on the RS Controller console. The Signalling & Train Control Contractor shall ensure that sufficient margin in the data packet size have been kept and the bit mapping of the packet contents are easily editable independent of the ATS software. The TOD shall have a refresh rate of minimum 1 second.
- 11.11.4.1.22 The Rolling Stock Contractor shall provide CCTV NVR, cameras and other associated equipment in the train which will cover cab, saloon, front of the train, rear view camera, area for passenger initiated alarm, platform area to obtain entraining and detraining of passenger view etc. The CCTV recorder (NVR) shall provide for minimum 7 days of recording on-board of commercial / revenue operation. The Rolling Stock Contractor and the Signalling & Train Control Contractor shall interface for control and data transfer of CCTV images from the train to OCC/BCC on Rolling Stock controller (RSC) terminal, separate terminal provide by ATS terminal and Large Video Screen. The hardware interface in the train shall be furnished and installed by the Rolling Stock Contractor. The CCTV signal shall be provided by the Rolling Stock Contractor at a suitable port on-board to the Signalling & Train Control Contractor for transmission to OCC/BCC. There will be no processing of the CCTV data by the Signalling & Train Control Contractor. At OCC/BCC at suitable terminals shall be able to select any camera on-board and view the recording live at any terminal/workstation. The Levels and protocols shall be agreed between the two contractors during design phase. A joint Detailed Interface Documents (DID) shall be submitted for Engineer's review.
- 11.11.4.1.23 The CCTV server shall be provided in OCC and BCC by Signalling & Train Control Contractor. The Signalling & Train Control Contractor shall interface with Rolling Stock Contractor for correct assessment of storage of all camera images to have virtual view of required area. Facility to transfer historic data for any event on demand from train to OCC/BCC shall be made available.
- 11.11.4.1.24 Necessary provision in terms of playing the historic data in OCC/BCC along with sufficient storage capacity to store data of 30 days shall be ensured in CCTV server. A joint Detailed Interface Documents (DID) shall be submitted for Engineer's review.

- 11.11.4.1.25 CCTV image feed received in OCC/BCC shall support buffering with 10 min pre data stored on memory cache of CCTV server. The GUI for viewing CCTV images shall support rewinding the images up to 10 min before real-time. Rolling Stock Contractor shall interface with Signalling & Train Control Contractor for transmitting all camera footage to central server and also viewing real time footage of any train, any camera from OCC/BCC.
- 11.11.4.1.26 Rolling Stock and Signalling & Train Control Contractors shall interface to ensure that at least but not limited to following emergency conditions should result in the event-based auto popup of CCTV images via CCTV network on RS Controller Terminal. In case of such event-based popup, the corresponding video stream from onboard train (5 min. pre and 15 min post recorded CCTV feeds) shall be stored automatically in the CCTV server provided in OCC/BCC. The detail implementation shall be finalized during interface with the approval of Engineer. The utilization of bandwidth of CCTV network shall be managed dynamically.
- PEA activation
 - Obstruction Deflection Device (ODD) activation
 - Side Door Obstacle detection
 - Fire/Smoke Detection
 - Driving console cover open
 - Detection of track abnormality by Track Monitoring System
- Transfer and display of such images from CCTV Server to LVS and Traffic Controller workstations shall be responsibility of Signalling & Train Control Contractor for which Rolling Stock and Signalling & Train Control Contractor shall interface.
- 11.11.4.1.27 Not used.
- 11.11.4.1.28 Rolling Stock Contractor shall make provision of CAT-7 or latest cable/Optical Fibre, power supply, switch (level 3) and space & bracket for mounting of Wi-Fi antennas & equipment in the train for Wi-Fi facility for passengers. The equipment for Wi-Fi in the train such as antennas, servers, etc. shall be supplied by Wi-Fi Contractor. Provision of dynamic bandwidth and its optimization for different uses shall be ensured suitably. Details shall be submitted for Engineer review during design phase.
- 11.11.4.1.29 Not Used
- 11.11.4.1.30 There shall be 4 separate radio system for communication between Train and wayside. The system will broadly cater to Train Radio (TETRA) traffic, CBTC traffic, CCTV traffic and Wi-Fi Traffic. The details of sharing of the 4 radio systems for sending control and data information, levels and protocols thereof, will be jointly agreed by Signalling & Train Control Contractor, Telecommunication Contractor, Rolling Stock Contractor and Wi-Fi Contractor. The radio system (including on-board equipment) for Train Radio traffic shall be provided by the Telecommunication Contractor while the radio system (including on-board equipment) for sending CBTC, CCTV and other data pertaining to passenger voice, control, alarm, events etc. shall be provided by the Signalling & Train Control Contractor including on board equipment. The bandwidth allocation on CCTV network shall be dynamically managed. Detailed proposal for the same shall be submitted by Signalling & Train Control Contractor for Engineer's review and approval.

- 11.11.4.1.31 The Rolling Stock Contractor shall prepare an interface document jointly with the Signalling & Train Control Contractor to address the procedures to be adopted for rescuing the failed train on main line by coupling the failed train with healthy train and subsequently clearing the line in pull/push mode with healthy train shall be submitted to the Engineer for review and approval.
- 11.11.4.1.32 Automatic Trains Operation System (ATO) and Unattended Train Operation system (UTO) shall operate in accordance with timetable schedules and energy saving regulation strategies to ensure smooth and efficient operation of Trains in both Mainline, Depot Arrival & Departure tracks and Test Track. It shall drive Trains automatically by using the traction and brake controls in a controlled manner, regulate the speeds of Trains, ensure accurate station stopping and perform platform duties or other functions otherwise assigned to the Train Operator.
- 11.11.4.1.33 **Roll Back Detection**
The ATP system shall detect rollback. When excessive rollback is detected, the emergency brake shall apply.

Rollback is defined as movement in the reverse direction when any of the forward driving modes are selected (UTO/ATO, ATP or RM) or movement in the forward direction when reverse mode is selected.

This predefined distance and speed shall be finalized by the Signalling & Train Control Contractor in interface with the Rolling Stock Contractor and the same shall be submitted by Rolling Stock Contractor for Engineer's review.
- 11.11.4.1.34 Signalling & Train Control Contractor and Rolling Stock Contractor shall interface for initiation, termination and success or failure of emergency calls initiated by passengers to OCC/BCC. The initiation of this passenger call shall automatically focus a CCTV camera on the passenger and raise a prompt on a suitable terminal of OCC/BCC. The hardware interface in the train shall be furnished and installed by RS Contractor. The Contractor shall submit the details for Engineer's review.
- 11.11.4.1.35 **Integrated Testing and Commissioning**
The Rolling Stock, Signalling & Train Control and PSD/PSG Contractors shall perform System Integration Test and the tests shall include but not limited to traction and braking control, precision stopping, automatic turn back, jog function, creep function, door operation, PSD/PSG operation, train wake up, PA/PIS functioning test, remote command and control for Rolling Stock, validating of modes of operation under Signalling (ATP/ATO/UTO), monitoring / troubleshooting from OCC/BCC/DCC to train (for UTO), reset commands jointly agreed by Rolling Stock Contractor and Signalling & Train Control Contractor as per requirement of GoA-4 mode of operation, safety related tests etc. All contractors shall jointly produce a protocol document for Integrated Testing and Commissioning for Engineer's review.
- 11.11.4.1.36 The Signalling & Train Control Contractor as a Lead Contractor shall prepare a comprehensive Operating Modes and Principle Document (OMPD). The Rolling Stock Contractor, PSD/PSG Contractor and Communication Contractor will assist the Signalling & Train Control Contractor in preparation of the document.
The Traction and Tunnel Ventilation Contractors will also assist the Signalling & Train Control Contractor in preparation of the documents. The Employer will provide necessary inputs such as standard operating procedures etc. The document shall establish the principles related to system and interface design under normal, degraded and emergency modes of operation. For each operating principle, the document shall describe the scenario, action to be taken by operator and system in a structured process flow chart. The additional requirement generated while preparing OMPD document shall be treated as the requirement within the contract without any cost implication.

- 11.11.4.1.37 The Rolling Stock Contractor and Signalling & Train Control Contractor shall implement automatic “sleep”, “wake-up”, “testing and dispatch etc. (pertaining to UTO mode of operation)” of trains stabled at depot/ siding /main line. Rolling Stock will send suitable signal through Signalling interface for display of indication and alarm at OCC/BCC/SCR/DCC level. The Rolling Stock Contractor shall submit details for Engineer’s review.
- 11.11.4.1.38 Train Event Recorder shall be provided by Rolling Stock Contractor, designed to resist tampering, that monitors and records data on train speed, direction of motion, time, distance, TBC position, brake applications and operations (including service brake, emergency brake) equipped, cab signal aspect(s) etc. Signalls from ATC/ATS side required to be recorded by Event Recorder & TCMS shall be decided during design phase and shall be tested during integrated testing and commissioning with Signalling & Train Control Contractor. The Rolling Stock Contractor shall submit the details for Engineer’s review.
- 11.11.4.1.39 In case of resumption of traction supply after failure/otherwise and when number of trains are standing in the section, ATS shall be capable of issuing sequential/staggered power on command and sequential/staggered starting of the train to avoid overloading of the Traction Supply. The Contractor shall submit the details for Engineer’s review.
- 11.11.4.1.40 In ATO/UTO modes of operation, Signalling & Train Control Contractor shall ensure that cross overs are negotiated in coasting mode only. In case the crossover cannot be negotiated in coasting due to factors such as gradient, minimum powering should be used to negotiate the cross over. Location of the cross over shall be identified by the ATC system and necessary train control should be implemented. In other modes of operation (ATP, RM, ROS, etc.), a coasting icon shall be displayed on the Signalling DMI when approaching a crossover to inform the train operator. The crossover information shall also be communicated to TCMS by the ATC system. Rolling Stock Contractor shall use this information to implement necessary controls in the propulsion system to avoid flashing at CCD and minimize inrush/overcurrent conditions in the propulsion and auxiliary circuits when train is moving on crossovers. Signalling & Train Control Contractor shall interface with Rolling Stock Contractor & Power Supply Contractor to finalize the same.
- 11.11.4.1.41 The Rolling Stock Contractor shall provide necessary signals to the Signalling & Train Control Contractor for proper functioning of Platform Screen Door/Gate (PSD/PSG). The Rolling Stock and Signalling & Train Control Contractor shall interface for exchange of signals and develop protocol for proper working of Platform Screen Door (PSD)/PSG.
- 11.11.4.1.42 Rolling Stock Contractor shall provide KE and door drawings of train to Signalling & Train Control contractor for placement of Platform Screen Doors/Gates and shall share the location of Emergency Access Device (EAD) and parking brake release lever with the Signalling & Train Control Contractor and also their operating mechanism. The Contractors shall also interface for synchronization of Train door & PSD/PSG opening and closing and for access of PSD/PSG Local Control Panel from train operator side.
- 11.11.4.1.43 Rolling Stock and Signalling & Train Control Contractors shall exchange the defective/Isolated train door and PSD door information so that if a particular train door is defective/isolated, the corresponding PSD shall not open and vice versa. Also, Rolling Stock, Signalling & Train Control and PSD Contractors shall interface for provision of reclosing the door(s) without opening all doors in case of obstruction detection.
- 11.11.4.1.44 Both the Rolling Stock and Signalling & Train Control Contractors shall log the commands and indications sent / received to / from the PSD/PSG system and the PSD/PSG system shall also Log the commands and indications sent / received from the Rolling Stock and Signalling & Train Control systems.

All the three systems shall be synchronized with a common clock system, and the Logs in each of the systems shall be so configured such it shall be possible to correlate the commands & indications sent/received from/to each of the three systems for post-incident analysis of incidents of PSD/PSG Train doors not opening / closing.

- 11.11.4.1.45 Additionally, in the event of a Train Door not opening due to a corresponding PSD/PSG at a Station being isolated (due to a fault /any other reason), the RS Contractor shall make arrangements to provide suitable indications on/for that particular door, for informing the passengers that this Door shall not Open at the next station and passengers may move to adjacent Doors. E.g. a Red LED/Lamp on each Train Door may be provided to indicate that the "Train Door shall not Open on the next Station". The RS contractor may use a multi-colour LED on the Train Door where- in yellow colour (steady / flashing) shall indicate normal operating status and RED colour (with suitable/associated stickers/screen printing) indicating a Fault condition of the Train Door (Door not opening).

Similarly, in the event of a PSD/PSG not opening due to a corresponding train door being isolated (due to a fault /any other reason), the Signalling & Train Control Contractor shall make arrangements to provide suitable indications on/for that particular PSD/PSG, for informing the passengers that this Door shall not Open when the train arrives and passengers may move to adjacent Doors.

Signalling & Train Control and RS Contractors shall interface together to provide the above functionality.

11.11.4.2 Rolling Stock Characteristics to be used by S&TC Contractor

- 11.11.4.2.1 The Signalling & Train Control system will work on moving block principle and the system shall be so designed to meet the headway requirements of 6-car train, based on the characteristics of the vehicles to be furnished (Annexure 1/D: Rolling Stock Characteristics) and the track geometry. The back-up (line-side) Signalling (In ROS/RM/cut out mode) shall use same axle counter as designed for the ATP working. Rolling Stock Contractor shall provide traction and braking characteristics of the actual vehicles and Signalling & Train Control Contractor must co-ordinate with Rolling Stock Contractor to fine-tune the system design based on the traction and braking characteristics of the actual vehicles furnished. Acceptance tests of the signal system will use the actual vehicles supplied. Brake capacity of the Rolling Stock shall be used optimally to ensure its maximum utilization when full brake equipment is operational. In case of isolation of any brake system or bogie/car, Rolling Stock Contractor shall furnish requisite information to Signalling & Train Control Contractor to optimize the brake rate including GEBR. However, GEBR shall never be compromised.
- 11.11.4.2.2 Not Used
- 11.11.4.2.3 The model for calculating the safe braking distance (SBD) shall identify and take into account various systems' response times and train operators' reaction times and shall be in accordance with IEEE 1474.1 standard. The design of CBTC system shall also take into account the effect of track geometry on the traction and braking characteristics. The Rolling Stock Contractor shall furnish the Guaranteed Emergency Braking Rate (GEBR) at the normal braking efficiency (with no isolation/bogie isolation / CAR isolation) and at the lowest braking efficiency permitted in service including brake deterioration to Signalling & Train Control Contractor. Rolling Stock Contractor shall also provide the speed-time-/acceleration- time curves between stations and speed/tractive effort curves, for all loading conditions. The system shall be designed to optimize train performance to the best of its capability.

- 11.11.4.2.4 The Rolling Stock Contractor shall furnish as a minimum the Rolling Stock parameters to be used by the Signalling & Train Control Contractor for designing the CBTC system, as set out in the attached Table (Annexure 1/D: Rolling Stock Characteristics). The Rolling Stock Contractor shall also furnish a reasonable tolerance band for the identified performance parameters. The Rolling Stock Contractor shall ensure that all the trains supplied perform within the tolerance band.
- 11.11.4.2.5 For any other information required by Signalling & Train Control Contractor, Signalling & Train Control Contractor shall co-ordinate with RS Contractor.
- 11.11.4.2.6 During the train operation, it may be desirable to optimize acceleration/ deceleration on the basis of varying loads/ line profile/ intended rising & falling gradients at entry/exit of the platforms. Rolling Stock Contractor and Signalling & Train Control Contractor shall resolve these issues during interface with the intention of optimizing train performance.
- 11.11.4.2.7 Rolling Stock Contractor and Signalling & Train Control Contractor shall share all the interface signals so as to enable logging / recording of these signals/data by either of them. During the design if any other signal needs to be shared for the purpose as above, the same shall also be ensured by either contractor.
- 11.11.4.2.8 The Rolling Stock Contractor shall provide optimized energy efficient run curve pattern to Signalling & Train Control Contractor for incorporation in the ATO/UTO mode of operation. All associated information as requested by Signalling & Train Control Contractor shall be duly handed over by Rolling Stock Contractor. The efficacy of the finalized run curves shall be jointly demonstrated by means of simulations as well as line trials. In this, Rolling Stock contractor shall take the lead role and Signalling & Train Control Contractor shall support Rolling Stock Contractor. Optimization of energy efficient mode shall consider different TE (Tractive Effort)/ BE (Braking Effort) curve for different loads as well. Contractor shall demonstrate optimization of energy with respect to different TE (Tractive Effort) /BE (Braking Effort) curve for different loads. Rolling Stock Contractor shall submit the details for Engineer's review.
- 11.11.4.2.9 The Rolling Stock Contractor shall provide facilities to detect any coupling detachment and/or separation of detachable units of a train consist. Upon detection of an impromptu uncoupling, detachment or separation, an immediate emergency braking to stop shall be invoked on all units of the connected train. The train parting information shall be shared by Rolling Stock to the Signalling & Train Control Contractor. On receiving the Signal from Rolling Stock, the ATC shall detect the unexpected uncoupling and establish appropriate limits of authority to prevent following trains from entering the area where the uncoupling has occurred. Consequently, an immediate alarm shall be raised and forwarded to the OCC/BCC/train operator.

11.11.4.3 S&TC details to be used by RS Contractor

11.11.4.3.1 The following data shall be provided:

- a) The maximum power consumed by the Signalling & Train Control contractor equipment from the 110V D.C. supply under all specified operating conditions.
- b) The number of train wires/ connections required, and the specific function of each wire/communication architecture and protocols.
- c) Physical dimensions of the equipment to be fitted on Rolling Stock.
- d) All control logic outputs.
- e) Electrical characteristics of the interconnection cabling and wiring.
- f) Sensitivity levels and frequencies which must be avoided.
- g) The specific heat load for air conditioning purposes.
- h) Specific ventilation requirements if any
- i) The EMC/EMI requirements including the limiting value of psophometric current, to obviate interference in the operation of Signalling & Train Control equipment.
- j) Details of the provisions required to enable the bidirectional transference of data from the train to the wayside and vice versa.

11.11.4.4 ATC Equipment Cubicles

- 11.11.4.4.1 The Rolling Stock Contractor shall supply the ATC equipment cubicle enclosure(s). All supports, braces, mounting holes, cabling apertures, accessories etc. required for mounting the cubicle and its equipment shall be properly Coordinated between the Signalling & Train Control Contractor and the Rolling Stock Contractor to ensure secure mounting, and access. The cubicle(s) shall be resiliently mounted and suitably protected to the requisite IP level. For housing of ATC equipment, suitable enclosed environment (minimum IP-52) needs to be provided by the RS Contractor.
- 11.11.4.4.2 To achieve the ATC control functions, the Signalling & Train control Contractor shall identify any interfacing circuits specifically required for ATC operation and liaise with the Rolling Stock Contractor. These include but not be limited to start, door control, motoring, coasting, braking and emergency brake commands. Door control circuit design shall allow opening of doors in stand by position of mode selector under manual responsibility in case of non-availability of door opening authorization from ATP without losing the ATP mode
- 11.11.4.4.3 For train control circuits, the Signalling & Train Control Contractor shall respectively identify the voltage free contacts to be provided by the Rolling Stock Contractor, including the number and type of electrical signals required between the ATP/ATO equipment and the equipment provided by the Rolling Stock Contractor. The two contractors shall co-ordinate to agree on levels and protocols for each such signal.
- 11.11.4.4.4 As a minimum, all electronic equipment to be mounted on Rolling Stock, including those provided by the Signalling & Train Control Contractor shall comply with IEC 60571: Electronic Equipment used on Rail Vehicles, for design, manufacture and testing, and shall use components purchased

against an internationally recognized quality assurance and reliability certification procedure. The enclosures provided by Rolling Stock shall comply with IP requirements specified by the Signalling & Train Control Contractor.

11.11.4.4.5 All cable connectors shall be identified within the cubicle using robust cable markers with distinctive colours for identification.

11.11.4.4.6 All labelling shall be in ENGLISH. Hand-written labels shall not be used.

11.11.4.5 Antennae

11.11.4.5.1 The Signalling & Train Control Contractor shall identify roof, bogie, and underframe-mounted antennae, and associated disconnection box mounting brackets and location requirements to identify cable and conduit routes required to antennae, as applicable.

11.11.4.5.2 The Signalling & Train Control Contractor for their respective scope, shall supply the necessary disconnection boxes, terminal blocks, cables and adaptation mounting brackets, flexible conduit assemblies complete with connectors and cables from antennae to the junction boxes.

11.11.4.5.3 The Rolling Stock Contractor shall provide the antenna mounting brackets, conduits, support or clamping arrangements to ensure security and reliability.

11.11.4.5.4 The antenna system shall not infringe the kinematic envelope and fully meet the radio coverage requirements, the requirements both for normal and reverse directions of train working.

11.11.4.6 Speed Measurement Devices

11.11.4.6.1 For each ATC equipment set (per driving cab), the Signalling & Train Control Contractor shall supply to the Rolling Stock Contractor for installation, axle mounting speed measurement devices, couplings & Radar, to be configured, and the data from them processed in such a way as to achieve the objectives of 24.6.4.6.3 below in fail safe manner.

11.11.4.6.2 The speed measurement device shall be mounted those axles, which are non- powered.

11.11.4.6.3 The Signalling & Train Control Contractor shall ensure that the speed measurement devices produce a signal which reflects the true speed of the train (within ± 1.0 km/h) under any operational, weather and track conditions including gradient, curvature, and wheel spin/slide. The error in the speed measurement due to wear in wheel diameter, up to the laid down limits shall be mitigated by automatic means or other safe method.

11.11.4.6.4 The Signalling & Train Control Contractor shall supply the necessary disconnection and terminal blocks, device mounting brackets and plates, flexible conduit assemblies complete with connectors and cables from speed measurement devices to the junction boxes. The Signalling & Train Control Contractor will supply all the mechanical fixing items like odometer, Antenna, Radar, pick up coil and cables required for ATC. like cables for Odometer, Antenna & Radar etc.

11.11.4.6.5 The Rolling Stock Contractor shall provide for each speed measurement device mounting brackets, support or clamping arrangements to ensure security and reliability.

- 11.11.4.6.6 The Signalling & Train Control Contractor shall furnish the zero-velocity detection apparatus (ZVR relay).
- 11.11.4.6.7 The Signalling & Train Control Contractor shall provide speedometer indicating the actual speed, and with target speed in digital format. The design shall be acceptable to the Engineer.
- 11.11.4.6.8 The Automatic Train Protection (ATP) system shall issue the braking commands to the Rolling Stock when safety limits are exceeded or when over-speed is detected. Removal of traction power and the correct application of brakes shall be the responsibility the Rolling Stock Contractor. The ATP system shall be responsible for monitoring of speed and the issuing of braking commands when safety limits are exceeded.
- 11.11.4.6.9 Parking brakes shall be provided by the Rolling Stock Contractor. The parking brakes shall be capable of holding a fully loaded stationary train on a 4% gradient under all track conditions, indefinitely.
- 11.11.4.6.10 The Signalling & Train Control Contractor shall furnish the Rolling Stock Contractor with full mounting details, apertures, fixing holes, etc.

11.11.4.7 Train Operator's Display

- 11.11.4.7.1 The equipment on driver's console used for various modes shall be ergonomically placed and shall be compliant to UIC 651. Indications to the train operator shall be displayed on the ATC Cab Display supplied by the Signalling & Train Control Contractor. It shall incorporate as a minimum, but need not be limited to the following information:
1. Train description, (ID) including crew identification.
 2. Target Distance.
 3. Target Speed.
 4. Actual Speed
 5. Service and Emergency Brake Initiation.
 6. Train docked along with the deviation distance from NSP.
 7. Trains hold status.
 8. Station dwell time available.
 9. Departure order.
 10. In ATP zone or not.
 11. ATP/ATO/UTO failure indications.
 12. Skip Stop indication.
 13. Door Indication (Door Close, Door Open).
 14. Maximum Permissible Safe Speed (MSS) in ATP, UTO and ATO Modes.
 15. Train stopped outside of expected stopping window.
 16. Depot indication, when the train is identified as being in a depot.
 17. Axle locked indication, for axles on which ATC speed sensors are mounted.
 18. Door release available; indicating on which side(s) of the train the doors may be opened.

19. Operating modes.
20. ATC self (combined) test in progress.
21. ATC self (combined) test OK.
22. ATC self (combined) test NOK.
23. Change of End.
24. Skip Station.
25. Cross-over Zone.
26. Work Zone.
27. Direction of Travel.
28. Door Closed and Locked.
29. Date, Time and Life Indicator.
30. Close Doors Order.
31. Open Doors Order
32. PSD/PSG Status (PSD/PSG/Closed/Open/failure detected /unknown...etc.).
33. Over Speed Alarm.
34. Slip/Slide Detection.
35. Roll Back Symbol.
36. Any other indication required for efficient / effective GoA4 train operations.

11.11.4.7.2 The DMI shall display following text messages in the event of EB for the below. It shall incorporate as a minimum, but need not be limited to the following information:

- a) EB: Train doors unlocked
- b) EB: Train hold applied
- c) EB: Over Speed
- d) EB: Fatal Faultg
- e) EB: safety immobilization not obtained
- f) EB: signal overrun
- g) EB: roll back
- h) EB: changing mode while running
- i) EB: Requested by ATS

During design stage, Rolling Stock and Signalling & Train Control Contractors shall have to interface to integrate TCMS/DMI inputs, if considered necessary to optimize the driving console in the cab for operation under GoA4. Also, Signalling & Train Control Contractor shall interface with Rolling Stock Contractor, to provide required inputs, like current speed, target speed, Normal Stopping Point (NSP), target distance and mode of the train, as a minimum, to Rolling Stock HMI for display purposes.

11.11.4.8 **Interface between TCMS and on-board S&TC equipment and OCC**

- 11.11.4.8.1 The Rolling Stock Contractor shall provide an on-board Train Control Management System (TCMS), to log the information from the ATP/ATO/UTO equipment supplied by the Signalling & Train Control Contractor, in addition to the information shown in the Rolling Stock specification. Signalling & Train Control Contractor shall provide required tools for reading ATC data stored in TCMS.
- 11.11.4.8.2 Data stored in the TCMS shall be password protected. Levels and protocols shall be agreed between the Contractors. Software for downloading the data from TCMS to maintenance terminal shall be provided by the Rolling Stock Contractor. Signalling & Train Control Contractor shall provide Windows compatible software for maintenance terminals for viewing the data logged in TCMS. It shall be possible to extract the data remotely from Rolling Stock depot server to a suitable terminal at OCC/BCC through the depot network.
- 11.11.4.8.3 All the vital commands by the on-board ATP, ATO and UTO systems, to the Rolling equipment and the responses of the Rolling Stock equipment to these commands, shall also be recorded in TCMS.
- 11.11.4.8.4 The signals to be supplied from the TCMS to the equipment of the Signalling & Train Control Contractor shall be decided jointly between the Contractors.
- 11.11.4.8.5 TCMS shall be able to communicate data to OCC/BCC/DCC/SCR on the Rolling Stock terminal of ATS system. The data shall contain identified train alarms. The Rolling Stock and Signalling & Train Control Contractors shall interface to make the data available to its destination in OCC/BCC/DCC/SCR.
- 11.11.4.8.6 The interface shall ensure that TCMS receives necessary inputs from the on-board ATP system to enable TCMS to synchronize its clock with the system master clock. All the microprocessor/ micro-controller based on-train systems shall synchronize respective clocks with TCMS clock.
- 11.11.4.8.7 The Signalling & Train Control Contractor and Rolling Stock Contractor shall liaise with each other regarding the electrical requirements on the TCMS interface. The Rolling Stock Contractor shall advise the Signalling & Train Control Contractor on the protocol of communication with the TCMS and the response time.
- 11.11.4.8.8 The data to be transmitted from the train borne ATC equipment to the TCMS and from the TCMS to the train borne ATC equipment shall be determined mutually by both the Rolling Stock and Signalling & Train Control Contractor and submitted to Engineer for review.
- 11.11.4.8.9 Not used

11.11.4.8.10 Control Output from ATC System to Rolling Stock

The Signalling & Train Control Contractor shall provide, but not limited to, the following outputs to the Rolling Stock:

- a. Emergency Brake Command
- b. Motoring command
- c. Service Brake Command

- d. Train stationary (zero velocity) signal & indication
- e. Door open command
- f. Door close command
- g. Door enable command
- h. Advance directional door display (left or right side)
- i. Defective PSD/PSG at upcoming station (individual door) signal
- j. ATC System Fault
- k. Wake up/sleep command
- l. Train Wash command
- m. Inching command
- n. CCD control command
- o. High beam
- p. Horn Command
- q. Saloon Lighting/Air-condition ON/OFF command

The details shall be submitted by Signalling & Train Control contractor in interface with the Rolling Stock Contractor as a joint interface document for Engineer's review.

11.11.4.8.11 Control Output from Rolling Stock to ATC

The Rolling Stock Contractor shall provide, but not limited to, the following outputs from the trains:

- a. Mode selector selection
- b. UTO mode
- c. ATC bypass switch
- d. Emergency brake
- e. Brake Pressure
- f. Brake defective/Brake isolation
- g. Train depart readiness
- h. Train door status – Open / Close / Defective / Manual Release operated / attempts Failure to close door after obstacle detection reclose
- i. Train Integrity status
- j. Smoke alarm
- k. CCD status
- l. Train alarms and status
- m. Obstruction detection alarm
- n. Track abnormality detection alarm
- o. Hot Axle detection alarm

The details shall be submitted by Signalling & Train Control contractor in interface with the Rolling Stock Contractor as a joint interface document for Engineer's review.

11.11.4.8.12 Key Alarms and Remote-Control Commands from OCC/BCC

The Signalling & Train Control Contractor and Rolling Stock Contractor shall coordinate to implement the following key alarms and remote-control commands from OCC/BCC. Below mentioned Alarms and Commands are bare minimum and shall not be construed as the entire list. Details shall be further discussed during design stage.

Key Alarms:

- a. Emergency Brake Applied
- b. Fire/Smoke detection inside train
- c. Emergency Egress Request
- d. EED cover broken
- e. Passenger Alarm Activation
- f. Driver desk cover opened
- g. Axle Lock
- h. No Light in any Car
- i. Train parting
- j. Failure of TCMS
- k. Train Fail to Start
- l. HSCB trip
- m. Obstacle / Derailment Detection
- n. Door Fail to Open (# of door)
- o. Door Fail to Close (# of door)
- p. Brake Fail to Apply/Release 'n' bogies (# of bogie)
- q. Traction Power Lost on 'n' Bogie (# of bogie)
- r. Smoke Detection outside train
- s. Failure of Fire Detector/ Fire Detection System
- t. Rail defect detected
- u. Failure of PEA
- v. Onboard CCTV Failure
- w. Speed restriction imposed due to
- x. Train in degraded mode

Remote Commands:

1. Door Open/Close

2. Emergency Brake Reset
3. Passenger Alarm Handling
4. Smoke Alarm Reset
5. Wake up/Sleep
6. CCD control
7. Inching movement
8. Wash Mode Control
9. HSCB Reset
10. Parking Brake Apply/Release
11. BLCOS (Brake loop cut-out)
12. Remote Isolation of Bogie for release of Service Brake only (Isolation shall not impact EB)
13. Compressor control
14. DPLCOS (Door Proving loop cut-out)
15. Door isolation
16. HVAC mode and temperature control
17. HVAC Reset Control
18. Damper Control
19. Interior Light Control
20. Stop all trains
21. ATC reset
22. Start-up tests
23. MCB reset
24. Door open in tunnel
25. Door Enable(DE)
26. PEA Reset
27. Flasher light On/ Off
28. Call on light control
29. Horn On/Off
30. Headlight On/Off
31. Cab light On/Off

The details shall be submitted by Signalling & Train Control contractor in interface with the Rolling Stock contractor as a joint interface document for Engineer's review.

11.11.4.8.13 Signalling and Train Control Contractor in interface with Rolling Stock Contractor shall implement the following features:

- i) When a Startup Test (i.e., Combined test) is failed, ATS operator shall be provided an option to Re-Lunch the test again from OCC/BCC.
- ii) There shall be provision to stable and un-stable the trains automatically with timetable, without timetable or manually.
- iii) Waking up of trains from stabling shall be staggered to avoid sudden inrush current at the same time.
- iv) If due to any reason, Level Crossing is required to be provided in the depot, then the Level Crossing shall be controlled through Signalling & Train Control system.
- v) When a fire/smoke detection notification is received from a Train, the Signalling & Train Control System shall command any following Trains which have already departed the platform in the rear to stop immediately and prevent any further movement once stationary until authorized to do so by the OCC/BCC.
- vi) When a fire/smoke detection notification is received from a Train, the Signalling & Train Control System shall command any Train travelling towards the incident Train or the area where fire/smoke has been detected to stop immediately and prevent any further movement once stationary until authorized to do so by the OCC/BCC.
- vii) When there are no passengers in the train in main line service or during train movement in depot, Air Conditioning and Lighting shall be switched off automatically through interface between Signalling and Rolling Stock.
- viii) In UTO mode, if train gets delocalized, the system should use memorized location so that train can move with less speed until next beacon. Once train passes the next beacon, train shall be localized and get normal speed authorization.
- ix) Light Sleep and Deep Sleep functions shall be implemented.
- x) The Rolling Stock Contractor shall provide an Automatic Track Monitoring System using high resolution Digital Line Scan Camera in two trains (4Cameras, 2 in each train) of Line-6 and 4 trains of Silk Board – Kempegowda International Airport corridor (8 Cameras, 2 in each train) i.e. 12 Cameras in total. The proposed track monitoring system shall be proven for similar metro rail applications. Track monitoring system shall detect track conditions such as rail fractures, running edge defects, rail head surface defects, corrosion, missing fasteners etc. in real time using artificial intelligence up to 90 kmph of train speed. An on-board module shall be provided in the train to analyse and process the images/video stream eived from the Digital Line Scan Camera and detect defects in the track. Critical defects along with exact location of the defects shall be communicated to OCC/BCC in real time through the CCTV network to be supplied by Signalling & Train Control Contractor. The list of critical defects to be communicated to OCC/BCC shall be finalized during design phase. Necessary interface shall be ensured between the Rolling Stock, Signalling & Train Control and Track monitoring system contractor to achieve the required functionality. The Rolling Stock Contractor shall supply the on-board Digital Line Scan Camera, necessary software and hardware such as servers, workstations and networking equipment in OCC/BCC and the trains. Signalling & Train Control Contractor shall ensure communication of detection of track defects to OCC/BCC.
- xi) EB shall be applied on detection of obstruction by the Obstruction Deflection Device (ODD). The information shall be transmitted to

OCC/BCC through Signalling & Train Control system. EB shall not be released unless the removal of obstruction is acknowledged by OCC/BCC or locally on the train.

- 11.11.4.8.14 Signalling and Train Control Contractor shall ensure synchronization between CATS, BATS, LATS and DATS.
- 11.11.4.8.15 The Signalling & Train Control Contractor shall ensure that non-vital signals from the TCMS are not used by the ATP system for generating/enabling Vital control outputs.
- 11.11.4.8.16 Considering that the vital outputs generated by the ATP are SIL-4, normally all such Vital Outputs should use only hardwired inputs provided by the Rolling Stock or alternatively, if signals from the TCMS are used, then these Signals should generally be SIL-2 and shall be exchanged using Safety Data Transmission between ATP and TCMS as finalized during design stage.
- 11.11.4.8.17 Notwithstanding the above, if use of the TCMS signals for generating control (output) signals by the ATC is inescapable, then such TCMS interface signals to the ATP, should be constituent of the VITAL packet, configured for Safety to desired SIL (Up to SIL2) (as per Contract requirement). Details shall be finalized during design.
- 11.11.4.8.18 Detailed implementation of such interface between TCMS & ATP, clearly and unambiguously identifying the mode of connectivity (Ethernet, Serial Interface or Hardwired) for each & every interface signal shall be finalized between RS & Signalling & Train Control Contractors, during the interface design and submitted for approval of the Engineer.
- 11.11.4.8.19 The TCMS & onboard ATC systems shall be connected with each other through redundant links (dual homing using independent communication ports for the redundant links on both TCMS and onboard ATC).
- 11.11.4.8.20 Staggered acceleration of the trains within the same power supply feeding zone shall be suitably ensured under UTO operation for both normal and extended feeding scenarios arising due to power supply disruption or bunching of trains within the same feeding zone as a part of interface design for avoiding tripping of HSCB of substation. Design shall be suitable for 90 sec headways. The details shall be submitted and finalized for Engineer's review during design phase.

11.11.4.9 Power Supply and Earthing Arrangements

- 11.11.4.9.1 Rolling Stock Contractor shall provide Independent 110V DC. Power supply circuits, as per interface document including positive and negative poles. At least three power supplies for the ATC Equipment shall be provided by the Rolling Stock Contractor and there shall be no physical or electrical links between these power supply circuits.
- 11.11.4.9.2 The Rolling Stock Contractor shall provide dedicated earthing arrangements for the train borne ATC equipment. The Signalling & Train Control Contractor shall specify the earth impedance required.

11.11.4.9.3 The power supply cable between the train power supply and the ATC train borne equipment power equipment shall be segregated, as short as possible and directly connected to the supply without any intermediate connection.

11.11.4.10 Factory Installation and testing

- 11.11.4.10.1 All the special equipment associated with the train borne ATC system, including the interface cables / wires shall be designed and supplied by the Signalling & Train Control Contractor to the Rolling Stock Contractor factory. Each contractor shall be aware of the locations of manufacturing plants, which could concurrently be manufacturing cars.
- 11.11.4.10.2 The Signalling & Train Control Contractor shall be responsible for providing all data and training of Rolling Stock Contractor's staff in all aspects of ATC installation and testing where applicable. In all train sets ATC equipment shall be installed by Rolling Stock Contractor, under the supervision of the Signalling & Train Control Contractor representatives, including the wiring for the interface of the ATC equipment with Rolling Stock.
- 11.11.4.10.3 The Rolling Stock Contractor shall be responsible for installation and wiring for equipment, and its testing on each car to the functioning standard agreed with the Signalling & Train Control Contractor.
- 11.11.4.10.4 Testing of each car shall comply with the accepted international standards agreed between the contractors as agreed with the Engineer. Initial integration tests (static) shall be done at the Rolling Stock factory and carried out by the test personnel of respective contractors jointly. Further main line integration tests will be required to be carried out to ensure all train control functions between OCC/BCC and Train which will be required to be done jointly by the Rolling Stock and Signalling & Train Control Contractor at site in Bangalore. The test certificate subsequently shall be issued jointly by the Rolling Stock and Signalling & Train Control Contractor. The certificates will pertain to the respective areas of the contractor's responsibility and shall be decided during the interface. Integrated testing of each train with Signalling & Train Control system shall be done as under:
- a) Signalling & Train Control Contractor shall develop ATC- Rolling Stock (RS) joint test procedure for mainline testing. It shall be the responsibility of Signalling & Train Control and Rolling Stock Contractors to jointly test each 6-Car train set on mainline as per the ATC-RS joint procedure.
 - b) Signalling & Train Control Contractor in interface with Rolling Stock Contractor shall develop a test procedure for obtaining the maximum energy saving in ATO/UTO mode over the entire section of corridor.
- 11.11.4.10.5 Rolling Stock Contractor shall provide facilities for comprehensive static and interface tests between the Rolling Stock, Signalling & Train Control systems at his premises. Signalling & Train Control Contractor shall be responsible for the provision of special test equipment and instrumentation.
- 11.11.4.10.6 In case of UTO /ATO, the Integration test between the Rolling Stock and the Signalling & Train Control Contractors shall include tests on mainline to confirm the realization of demanded acceleration and deceleration rate by the UTO/ATO under various conditions.

- 11.11.4.10.7 Should the need arise for modifications in the configurations of respective equipment or systems as a result of Integration Test or otherwise, the scope of work and division of responsibility shall be jointly agreed amongst the contractors and detailed procedure shall be developed. The Rolling Stock Contractor shall provide the requisite manpower to monitor and/or implement the modifications on the Rolling Stock.
- 11.11.4.10.8 The Rolling Stock Contractor and Signalling & Train Control Contractor shall fully associate and render all necessary support during type testing of the respective systems. Rolling Stock type test may require all out mode of operation in GoA4 as per approved test specifications. The Rolling Stock Contractor and Signalling & Train Control Contractor(s) shall jointly finalize such test plan and schemes/operational modes and ensure the satisfactory completion of type tests.
- 11.11.4.10.9 For UTO, the critical scenarios under OMPD shall be type tested. The preparation of joint interface test specification shall be the responsibility of Signalling & Train Control Contractor. RS contractor shall assist in preparation and shall coordinate for review and approval of the same by the Engineer.

11.11.4.11 EMC/EMI Interface

- 11.11.4.11.1 With respect to electromagnetic interference, the Signalling and Train Control Contractor shall provide a list of frequencies and any other EMC/EMI requirements to the Rolling Stock Contractor, to enable the Rolling Stock Contractor to avoid such frequency bands in design, and to provide devices to isolate the source of potential emission wherever required. The Signalling and Train Control Contractor shall have first right of use for radio frequency (2.4 GHz, 5.8GHz or any other free band notified by WPC) for CBTC application.
- 11.11.4.11.2 The Rolling Stock and Signalling & Train Control Contractors shall ensure that the emission and immunity level of their respective equipment meet the requirements of EN50121-3-1 and EN50121-3-2.
- 11.11.4.11.3 The Rolling Stock Contractor shall ensure that the return current in the track at the specified frequencies does not exceed the value specified by Signalling & Train Control Contractor.
- 11.11.4.11.4 The Contractors shall also jointly develop a test plan for verification of electromagnetic compatibility of Traction, Signalling & Train Control system and also Communication systems. The Contractors shall work together to assure that all electronic and electrical equipment on the Rolling Stock works properly without interfering with Signalling & Train Control and Communication sub-systems.
- 11.11.4.11.5 The cable layout of the Signalling & Train Control system in the cable ducts provided by the Rolling Stock Contractor shall be jointly agreed. The separation between Signalling & Train Control cables and power cables of 750 V DC, 415 V three phase AC, 230 V AC single phase, 110 V DC rating shall be in accordance with accepted international practice and jointly agreed.
- 11.11.4.11.6 The cable ducts shall be earthed at notionally at every 2 m and also at the ends and shall be in accordance with accepted international practices.

11.11.5 Division of Responsibility

- 11.11.5.1 The Signalling & Train Control and Rolling Stock Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to those mentioned in Table-24.6.5.

11.11.5.2 These shall include the following but not limited to:

S. N.	Subject	Signalling & Train Control Contractor's Responsibilities	Rolling Stock (RS) Contractor's Responsibilities
1.	On board ATC/ATP Equipment	<ul style="list-style-type: none"> • Shall supply & deliver the equipment to the Rolling Stock Contractor's Works. • Shall supply Odometer, Radar and associated equipment for measuring speed in ATC mode. 	<ul style="list-style-type: none"> • Shall provide space in the vehicle design for fixing and installation at the manufacturer's facility, under the supervision of Signalling and Train Control Contractor. • Shall supply speed measuring sensor and other associated equipment for non-ATC mode.
2.	On board UTO and ATO equipment		
3.	Antennae for ATP, ATS, etc.		
4.	Speed measuring sensors, speedometer, odometer, Radar etc.		
5.	ATO/ATP/ATC Cab Displays (Train operators MMI) including special cables etc.		
6.	Antennae for CBTC, CCTV/multimedia including special cables etc.	• Shall supply the equipment to the Rolling Stock Contractor's Works.	• Shall provide space in the vehicle design for fixing and installation at the manufacturer's facility, under the supervision of the Signalling & Train Control Contractor.
7.	Train Lines /Ethernet Connection/Repeaters/Communication architecture and media	• Shall specify at an early date the requirement of Train lines / Ethernet Connection / Repeater/Communication architecture and media.	• Shall provide the necessary train lines / Ethernet Connection / Repeater/Communication architecture and media as per agreed interface.
8.	Power supply and earthing for on board ATP/ATO/UTO equipment	• Shall furnish required voltage values and earthing requirements to Rolling Stock Contractor for his scope.	• Shall provide the required voltages and earthing.

S. N.	Subject	Signalling & Train Control Contractor's Responsibilities	Rolling Stock (RS) Contractor's Responsibilities
9.	Logging of on-board information from ATP/ATO/UTO	<ul style="list-style-type: none"> • Shall supply data logger. • Shall facilitate identification of system level faults and segregate the faults on account of Rolling Stock or Signalling & Train Control System. • Shall co-ordinate with Rolling Stock Contractor for signal levels and protocols. • Shall supply the software required to read the ATC logs. 	<ul style="list-style-type: none"> • Shall provide the recording and monitoring of signals and faults from ATC in TCMS. • Shall supply TCMS. • Shall demonstrate the downloading of on-board ATC logs manually & remotely.
10.	Interface between ATP/ATO/UTO with train braking and propulsion systems for automatic braking, acceleration and deceleration	<ul style="list-style-type: none"> • Shall provide the requirements to the RS Contractor. • Shall supply ZVR & redundant EBR relays (within the ATC). • Shall provide redundant (dual homed) connections between ATC/ATO & TCMS for transmission of Traction/Braking demand with safety data transmission protocol. • Shall interface with Rolling Stock Contractor to transfer the Traction/Braking demand at agreed levels to Traction Inverter & EBCU through hardwired connection in case of failure of TCMS (Creep mode) under ATC supervision. 	<ul style="list-style-type: none"> • Shall co-ordinate with Signalling & Train Control Contractor to agree on levels and protocols for interface signals. • There shall be no delay in braking from Rolling Stock during the transition from ED to friction brake at slow speed. • Shall supply, install & incorporate in VCC the auxiliary relays for ZVR & EBR for additional contacts required. • Shall provide redundant (dual homed) connections between ATC/ATO & TCMS for transmission of Traction/Braking demand with safety data transmission protocol. • Shall provide redundant TCMS communication networks to transfer the Traction/Braking demand from ATC/ATO to Traction Inverter & EBCU. • Shall interface with Signalling & Train Control Contractor to transfer the Traction/Braking demand at agreed levels to Traction Inverter & EBCU through hardwired connection in case of failure of TCMS (Creep mode) under ATC supervision.
11.	System master clock	<ul style="list-style-type: none"> • Shall provide master clock information to TCMS. 	<ul style="list-style-type: none"> • Shall synchronize TCMS clock with the system master clock. • Shall synchronize all subsystems clock in Rolling

S. N.	Subject	Signalling & Train Control Contractor's Responsibilities	Rolling Stock (RS) Contractor's Responsibilities
			Stock with the TCMS clock.
12.	On board station (station arrival, current station, next station, skip station) Information/announcement to the passengers	<ul style="list-style-type: none"> Shall provide necessary signals / bits on-board to Rolling Stock Contractor. 	<ul style="list-style-type: none"> Shall provide for necessary hardware interface, display for on-board P.A. system inside the cars. Shall perform on-board announcements & displays based on the Signal/bits received from ATC. Shall ensure that the signals/bits received from ATC are displayed on a suitable page in TCMS.
13.	Climatic requirements for on board ATP/ATO/UTO equipment	<ul style="list-style-type: none"> Shall specify at an early date, the total heat load wattage, and maximum permitted temperature. 	<ul style="list-style-type: none"> Shall provide conditioning air from the saloon to all relevant Signalling & Train Control installations to maintain a nominal temperature of 25°C. Shall provide conditioned air ventilation for the console & cubicles.
14.	EMI/EMC interface between the Rolling Stock and Signalling and Train Control	<ul style="list-style-type: none"> Shall detail the EMI/EMC requirement and advise EMI/EMC plan for ATP/ATO equipment to Rolling Stock Contractor at early date. Shall jointly ensure the compliance with Rolling Stock. Shall provide support to Rolling Stock Contractor in conducting necessary EMI/EMC interface tests and assist in the preparation of report. 	<ul style="list-style-type: none"> Shall ensure the compliance of the EMI/EMC requirements for Signalling & Train Control on board equipment. Shall conduct necessary EMI/EMC tests and submit report in coordination with Signalling & Train Control Contractor.
15.	Train Integrity Information	<ul style="list-style-type: none"> Shall ensure ATC on-board receives Train integrity information as supplied by Rolling Stock. 	<ul style="list-style-type: none"> Shall provide Train Integrity information to ATC on-board.
16.	Data transmission methodology for control command	<ul style="list-style-type: none"> Shall interface with Rolling Stock Contractor for selection of best suited methodology i.e., bit by bit, code (1 byte) or any other. 	<ul style="list-style-type: none"> Shall provide details for ATC to TCMS Communication.
17.	The polling cycle and delay times assessment between OCC/BCC and on-board	<ul style="list-style-type: none"> Shall assess and furnish to Rolling Stock Contractor the polling cycle time, data transmission time (rate) between OCC/BCC and on-board ATC/CCTV 	<ul style="list-style-type: none"> Shall provide TCMS to ATC/CCTV interface requirements to Signalling & Train Control Contractor to comply with functionality as specified in the Rolling

S. N.	Subject	Signalling & Train Control Contractor's Responsibilities	Rolling Stock (RS) Contractor's Responsibilities
	ATC/CCTV	under best and worst case scenarios for both CBTC and CCTV networks.	Stock contract.
18.	OCC GUI for Rolling Stock controller	<ul style="list-style-type: none"> • Shall interface with Rolling Stock Contractor for transmission of the train operation data required for the OCC GUI from the trains to OCC/BCC via the Signalling CCTV network. • Shall be responsible for transmission and display of the OCC GUI from RS Controller workstation to the Large video screen/monitor (LVS). • Shall provide necessary support during interface finalization to the Rolling Stock Contractor. 	<ul style="list-style-type: none"> • Shall be responsible for development of the GUI (including hardware) for the Rolling Stock controller (RSC) in the OCC/BCC. • Any other GUI(s) in OCC/BCC shall not be the scope of Rolling Stock Contractor.
19.	Guaranteed Emergency Brake Rate (GEBR)	<ul style="list-style-type: none"> • Shall use the Guaranteed Emergency brake rate (GEBR) value given by Rolling Stock Contractor in their design. 	<ul style="list-style-type: none"> • Shall furnish value of GEBR to Signalling & Train Control Contractor.
20.	Emergency Brake application validation at low speed (≤ 25 kmph) as a part of wake-up procedure	<ul style="list-style-type: none"> • Shall validate the EB Test based on details furnished by Rolling Stock Contractor. 	<ul style="list-style-type: none"> • Shall furnish the pass/fail criteria based on the speed achieved and gradient of the track to the Signalling & Train Control Contractor.
21.	Live streaming from RS on-board CCTV to OCC/BCC and Live transmission of advertisements from OCC/BCC to train via CCV network	<ul style="list-style-type: none"> • Shall provide the CCTV network and suitable buffering arrangement for live video streaming (at server of OCC/BCC) transmitted from the train to the OCC/BCC via CCTV network and for its onward multicast transmission to other terminals / networks and for transmitting Videos/ Images/ Text etc. from OCC/BCC to Train. 	<ul style="list-style-type: none"> • Shall provide suitable interface with CCTV camera / Recorder (NVR) so that Signalling & Train Control Contractor can fetch live stream to OCC/BCC. • Shall provide suitable Buffering arrangement on the train for live video streaming, Live video players with buffering capability, Advertisement and Live video players in hot standby per train and Redundant suitable arrangement (video controller/player/servers) in OCC/BCC for transmission of live video contents and stored video contents to be played in the train.

S. N.	Subject	Signalling & Train Control Contractor's Responsibilities	Rolling Stock (RS) Contractor's Responsibilities
22.	Negotiation of cross- overs	<ul style="list-style-type: none"> • Shall ensure that cross overs are negotiated in coasting mode in ATO/UTO modes. • Shall use minimum powering to negotiate the cross over in case the crossover cannot be negotiated in coasting due to factors such as gradient. • Shall identify location of the cross over by the ATC system and necessary train control should be implemented. • Shall display a coasting icon on the Signalling DMI in other modes of operation (ATP, RM, ROS, etc.) when, approaching a crossover to inform the train operator. • Shall communicate the crossover information to TCMS by the ATC system. 	<ul style="list-style-type: none"> • Shall use this information to implement necessary controls in the propulsion system to avoid flashing at CCD • Shall minimize inrush / overcurrent conditions in the propulsion and auxiliary circuits when train is moving on crossovers.
23.	Platform Screen Doors/Gates	<ul style="list-style-type: none"> • Shall design and install the PSD/PSG based on KE and door drawings of train received from Rolling Stock Contractor. • Shall ensure alignment of the PSD/PSG with the train doors. • Shall incorporate the information regarding EAD and parking brake release levers on the Rolling Stock in • the design of the PSD/PSG system to ensure access to the EAD and parking brake release levers from platform. • Shall exchange the defective / isolated PSD/PSG information with RS Contractor for disabling opening/ closing corresponding RS and PSD/PSG. • Shall interface with Rolling Stock Contractor for synchronization of train door/PSD/PSG opening and closing. 	<ul style="list-style-type: none"> • Shall provide KE and door drawings of train to Signalling & Train Control Contractor for placement of Platform Screen Doors/ Gates. • Shall share location of EAD and parking brake release lever along with their operating mechanism with Signalling & Train Control Contractor. • Shall interface with Signalling & Train Control Contractor for synchronization of train door / PSD/PSG opening and closing. • Shall exchange the defective / isolated train door information with Signalling & Train Control Contractor for disabling opening/closing corresponding RS and PSD/PSG. • Shall prevent a train door from opening in case its corresponding platform screen door is under failure/ isolated. • Shall display message at relevant train door prior to

S. N.	Subject	Signalling & Train Control Contractor's Responsibilities	Rolling Stock (RS) Contractor's Responsibilities
		<ul style="list-style-type: none"> Shall prevent a platform screen door from opening in case its corresponding train door is under failure / isolated. Shall display message at relevant PSD/PSG prior to train arrival to notify passengers that the particular PSD/PSG will not open in case of defective train door on an arriving train, based on location of the defective train door shared by Rolling Stock. Shall restrict the speed of train to below 20 kmph and provide horn blow command to RS while entering/ leaving the platform area On receiving the Local Door Bypass Signal from PSD/PSG, 	<p>train arrival to notify passengers that the particular train door will not open in case of defective PSD/PSG on upcoming station, based on the location of the defective PSD/PSG shared by the Signalling & Train Control system.</p> <ul style="list-style-type: none"> Shall interface with Signalling & Train Control Contractor for the provision of reclosing the door(s) without opening all doors in case of obstruction detection. Shall blow horn while entering / leaving the platform area Based on the command from Signalling & Train Control system regarding Local Door Bypass Signal from PSD/PSG.
24.	On board equipment for CCTV image transmission to OCC/BCC	<ul style="list-style-type: none"> Shall provide necessary equipment on-board to Rolling Stock Contractor for image transmission to OCC/BCC. 	<ul style="list-style-type: none"> Shall provide for necessary on-board cameras, display equipment and inter connections as well as space and appropriate interface / protocols for Signalling & Train Control equipment.
25.	Limitations of Return Current for proper functioning of ATC	<ul style="list-style-type: none"> Shall provide the return current limits. 	<ul style="list-style-type: none"> Shall ensure the compliance of the requirements of Signalling & Train Control Contractor for ATC.
26.	Reading software tools for reading the ATC data from TCMS	<ul style="list-style-type: none"> Shall provide the same. 	<ul style="list-style-type: none"> Shall interface with Signalling & Train Control to obtain software tools for reading ATC data recorded in TCMS.
27.	Automatic Turn Back (ATB) function	<ul style="list-style-type: none"> Shall provide the ATB features as specified in Employer's requirement and shall also interface with RS Contractor for Rolling Stock circuit (VCC) design to achieve ATB function. 	<ul style="list-style-type: none"> Shall interface with Signalling & Train Control contractor and shall make necessary circuit (VCC) design as per Signalling requirement to achieve ATB function.
28.	Rollback Protection	<ul style="list-style-type: none"> Shall provide Roll Back protection system in ATC. 	<ul style="list-style-type: none"> Shall interface with Signalling & Train Control Contractor to achieve the rollback protection. system.
29.	Remote Controlled Resetting Commands	<ul style="list-style-type: none"> Shall be jointly discussed, finalized and implemented during design phase. Joint test protocols shall also be finalized and 	<ul style="list-style-type: none"> Shall be jointly discussed, finalized and implemented during design phase. Joint test protocols shall also be finalized and

S. N.	Subject	Signalling & Train Control Contractor's Responsibilities	Rolling Stock (RS) Contractor's Responsibilities
	from OCC/BCC to facilitate GoA-4 mode of operation	implemented.	implemented.
30.	Wheel Flange Lubricator (WFL)	<ul style="list-style-type: none"> Shall provide signals/bits to TCMS for identification of curve location (curve start & curve end). 	<ul style="list-style-type: none"> TCMS shall trigger WFL ON/OFF operation based on ATC signals/bits (curve start & curve end). Shall make available ON/OFF status and WFL system healthy status in TCMS.
31.	Automatic Track Monitoring System	<ul style="list-style-type: none"> Shall communicate critical defects such as rail fractures, running edge defects, rail head surface defects, corrosion, missing fasteners etc. as received from Rolling Stock along with exact location of the defects to OCC/BCC in real time through the CCTV network supplied by Signalling & Train Control Contractor. Shall ensure communication of camera images corresponding to track defects to OCC/BCC. 	<ul style="list-style-type: none"> Shall provide and install high resolution Digital Line Scan Cameras in two trains of Line-6 (4 Cameras, 2 in each train) and 4 trains of Silk Board – Kempe Gowda International Airport corridor (8 Cameras, 2 in each train) i.e., 12 Cameras in total and on-board module in the train. Shall analyze and process the images / video stream received from the Digital Line Scan Camera. Shall identify suitable location in the train to install the cameras and other associated equipment. Shall supply necessary software and hardware such as servers, workstations and networking equipment in OCC/BCC and the trains. Shall transmit the track defect information to Signalling & Train Control system.
32.	Obstruction Detection	<ul style="list-style-type: none"> Shall transmit obstruction detection information along with the ODD camera view as received from Rolling Stock to OCC/BCC. 	<ul style="list-style-type: none"> Shall provide Obstruction Deflection Device (ODD) on train. Shall transmit the detection information and ODD camera view to Signalling & Train Control system.
33.	Standalone door operation	<ul style="list-style-type: none"> Shall give standalone door operation command to allow driver / cleaning staff to enter / exit the train from designated door in designated Depot area / Main line siding. 	<ul style="list-style-type: none"> Shall give the necessary support to the Signalling & Train Control Contractor.

Rolling Stock Characteristics

Train composition	*DMC-TC-MC-MC-TC-DMC*
Average Acceleration rate from 0 kmph to 30 kmph	1 m/s ² ± 5%
Average service deceleration from 80 to 0 km/h	0.95 m/s ² ± 5%
Minimum average emergency deceleration	1.3 m/s ²
Maximum Jerk	0.7 m/s ³ ± 0.05
**Service Brake Response Time	<2 sec
**Emergency Brake Response Time	<1.5 sec
**Service and Emergency Brake Release Time	<2.5 sec
Resistance to motion (formula, curve, starting resistance)	$R = 14.01 + 0.264V + 0.00191V^2$ (N/ton) for at-grade and Elevated corridors. $R = 21.96 + 0.4222V + 0.00876V^2$ (N/ton) For underground corridor. Where R→Train Resistance (N/ton) V→Train speed (km/h)
Maximum wheel diameter	860mm
Minimum wheel diameter	780mm
Maximum train design speed	90kmph
Maximum train service speed	80kmph
Door opening and closing times	Opening time: 2.5 s (± 0.5s) Closing time: 2.5 s (± 0.5s)
No. of axles per Car	4
Presence of non-service brake and non- powered axles	All DMC and MC car axles are powered while those of TC-cars are non-powered. All axles are friction braked.
Maximum Axle Load	15 Tons

Train length – 6 Car Train	130.3 m
----------------------------	---------

Notes:

1. All of the data in the above table are notional, and should be confirmed between the Contractors during design Phase.
2. For the items marked **, the timings are for a brake application from full release to 90% of full brake cylinder pressure, and for brake release from full brake cylinder pressure to 10% as per EN 13452-1.

Communication shall be configurable between any of these user groups.

11.12 INTERFACES WITH TELECOM CONTRACTOR**11.12.1 Scope of Work**

11.12.1.1 The Contractors shall as a minimum interface with the following sub-systems:

- (i) ATS – PIDS
- (ii) ATS – PAS
- (iii) TETRA – ATS/ATC
- (iv) Optic Fibre – ATS, IXL, and ATC
- (v) GE – ATS
- (vi) UPS Supply for the TER (Telecommunication Equipment Room), CER (Central Equipment Room).
- (vii) Video Transmission (Radio) system – CCTV System

11.12.2 Interface of S&TC System with Public Information Display System (PIDS)

11.12.2.1 The Contractors shall interface for automatic display of train related information including train arrivals/ departures on pre-designated display boards.

11.12.2.2 The ATS for a specific sector of the S&TC System shall send data to the PIDS to display train related information including train arrivals and departures and train composition on pre-designated display boards throughout the platforms and the concourse of all stations.

11.12.2.3 Based on the information received from the S&TC System, the PIDS system will initiate and co-ordinate Train arrival/ departure and train composition related PIDS message with the Public Address System.

11.12.2.4 The PIDS will carry out time countdown based on the estimated time data sent by the S&TC System and display the estimated train arrival and /or departure Particulars. The estimated time to arrive and / or depart of the train(s) as shown on any display board will be updated automatically and will be corrected if necessary, following a data update from the S&TC System. The pre-defined message displays will be triggered by the data sent by the S&TC system including message displays of non-stopping trains passing through the stations, train not in service and user defined message displays.

11.12.2.5 The S&TC equipment at each station shall invoke the station PIDS control equipment to clear the designated row of the train arrival/ departure information on the corresponding PIDS display boards subsequent to a train departure.

11.12.2.6 The two Contractors shall jointly develop detailed interface document covering the hardware interface, list of messages, type and format of message to be displayed and the protocols to be followed for exchange of data between the two systems. The detailed interface document shall be submitted for review of the Employer.

11.12.3 Interface of S&TC System with Public Address System (PAS)

11.12.3.1 The Contractors shall interface for automatic announcement of train related information including train arrivals/ departures on the designated station platforms.

11.12.3.2 Data shall be sent by the S&TC to the PAS System in a coordinated manner to broadcast predefined train information including train arrivals and departures on pre-designated display boards throughout the platforms of all stations.

11.12.3.3 PAS announcements will be made to alert passengers of all non-stopping trains and as well as arriving train's composition based on the information received from the S&TC System.

11.12.3.4 The PAS will carry out the time countdown based on the estimated time data sent by the S&TC System. The estimated time to arrive and/or depart of the train(s) will be stepped down automatically every minute and will be corrected, if necessary, following a data update from the S&TC System.

11.12.3.5 The time countdown will be frozen when a train stops proceeding to the next stopping station, due to circumstance detectable by the S&TC System and relayed to the PAS.

11.12.3.6 The pre-defined announcements will be triggered by the time countdown functions of the PAS or data sent by the S&TC System including announcement of non-stopping trains passing through the station.

11.12.3.7 The two Contractors shall jointly develop detailed interface document covering the hardware interface, type and format of message to be displayed and the protocols to be followed for exchange of data between the two systems. The detailed interface document shall be submitted for review of the Employer.

11.12.4 Interface of S&TC System with Radio System

11.12.4.1 The Contractors shall interface to achieve reporting of the alarm and status of the Train borne Signalling and Train Control Equipment by Radio to OCC through a Communication Port.

11.12.4.2 The Train Radio shall obtain the passenger-initiated alarm button ID from the onboard Rolling Stock system and transmit the same to Central ATS

- 11.12.4.3 S&TC system shall interface with Train Radio for Dynamic Registration of Train identity numbers (TID) using the information provided by the ATS system.
- 11.12.4.4 The Onboard ATP system shall interface with the Train radio to enable the Train radio automatically transmit alarm message to the OCC whenever the mainline revenue Train has switched to Restricted Mode (RM) operation. This detection shall, however, be disabled for Trains operating in the depots.
- 11.12.4.5 As a minimum the RM operation indication shall appear on the Traffic Controller's Radio Dispatcher Console and shall contain the Train Identity Number (TID), Rake ID, location from which it is originated (in terms of which Radio Base Station the alarm message was originally routed). The alarm message shall be time and date stamped. Radio Dispatcher Console shall be able to send an acknowledgement and initiate a call, both voice and short data message to the Train. This service shall operate regardless of whether the Train driver or the target user is engaged in a voice or data call.
- 11.12.4.6 Failure of the radio equipment shall not interrupt the normal operation of the Train borne ATC equipment.
- 11.12.4.7 The Signalling & Train Control and Communication Systems Contractor shall jointly develop detailed interface document covering the hardware interface, list of messages, type and format of message to be displayed and the protocols to be followed for exchange of data between the two systems. The detailed interface document shall be submitted for review of the Employer.
- 11.12.4.8 Safety Communication: All communication between Operations Control Centre and roving attendant, Station Controller, maintenance staff of Electrical/Traction, Rolling Stock, Signal and Telecommunication and Track structures department and other pertaining to movement of trains shall be recorded with time stamping, and preserved for incident analysis and training. The mode of preservations and its duration shall be specified in special instructions.

11.12.5 Interface of Master Clock – ATS System

- 11.12.5.1 The Communication Contractor shall provide Sub-master Clocks at OCC & BCC for meeting the clock synchronization requirements of Signalling, Communication and other systems. The Signalling servers/ workstations, routers etc. shall synchronize through sub-master clocks through Signalling LAN/ communication LAN (as per design proposed by Signalling Contractor).

11.12.6 Interface of UPS – Communications

- 11.12.6.1 The Power Supply system (UPS system, batteries, 240 V AC output) will be supplied, installed and tested by the Signalling & Train Control Contractor. The power connections between the UPS room and the TER will be supplied and installed by the Communications Contractor. The power requirements for the Communication system shall also be provided by the Communications Contractor.
- 11.12.6.2 The Signalling & Train Control Systems Contractor shall connect the cable(s) provided by the Communications Contractor to the dedicated UPS interface.

11.12.6.3 The Ethernet interface will be provided by the Signalling & Train Control Systems Contractor for the UPS monitoring purposes on the CCFRS from each Station/DCC.

11.12.6.4 All alarms and displays generated by the UPS shall be monitored through the OCC using an appropriate interface. All alarms and displays to be jointly agreed by the Signalling & Train Control Systems Contractor.

11.12.7 Division of Responsibility

11.12.7.1 The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Item Description	S&TC Contractor	Telecom Contractor
1	PAS/PIDS	<ul style="list-style-type: none"> Provision of protocols and automated messages from the ATS with Telecom Contractor for integrating purpose. Shall provide the necessary cables from the SER to the TER/CER for PA/PIDS integration. 	<ul style="list-style-type: none"> Provide all cables, assemblies and fixtures in stations for PA speakers and Passenger Information Display units. Shall provide all necessary physical connection ports in the TER/CER for connecting of the cables for integrating the ATS messages for the PA/PIDS system.
2	TETRA – AC/ATS	<ul style="list-style-type: none"> Shall provide the protocol and message format for information with respect to Train data for all Trains located on the mainline and within the Depots. The format shall adopt the protocols between the ATC cubicle and the Radio system. Then the Signalling and Communication Contractors shall agree a usable format for the transmission and receiving of data. The cable (RS 422) from the ATC cubicle to the Radio system shall be provided. 	Shall Integrate with the Signalling and Train Control system for the interfaces between the ATC system and Radio system.
3	GPS synchronized clock system	Shall synchronize internal system clock of Signalling and Train Control system with the Clock system	Shall provide the GPS synchronized Clock signal to the Signalling and Train Control system.
4	UPS supply for TER (Telecommunication equipment room), CER (Central equipment room) and all communications equipment rooms	<ul style="list-style-type: none"> Shall provide UPS in UPS room as per the capacities identified in the technical specification of Signalling & Train Control Contractor. Shall provide separate MCBs for the Communications equipment, TER (Telecom Equipment Room), CER (Central Equipment Room). 	<ul style="list-style-type: none"> Specify the maximum load requirements for all the Communications equipment including SCR. Shall provide and lay the power cable from UPS to TER & CER. Receive and display status alarms/messages from the UPS equipment as per the requirements of the Telecom Contractor.

Item No.	Item Description	S&TC Contractor	Telecom Contractor
5	Optimization of cable routing in depot	<ul style="list-style-type: none"> Send and integrate the alarm status of the UPS as per the Engineer's requirements to the CSS. Provide necessary cables to the Telecom Contractor. Shall interface suitably with Communication System provider to ensure proper cable routing in cable ducts and trays in depot and station area.	Shall interface suitably with Signalling and Train Control System provider to ensure proper cable routing in cable ducts and trays in depot and station area.

11.13 INTERFACES WITH POWER SUPPLY CONTRACTOR

11.13.1 The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Item Description	S&TC Contractors	PST Contractor
	Design Stage		
1	Various interfaces	Shall interface, provide necessary inputs, share information and seek information from PST Contractor: <ul style="list-style-type: none"> EMC/EMI study related (provide S&TC cable location, specs etc.) SCADA system design at OCC (shall lead ergonomic design) Provide earthing & bonding related inputs, including track-circuit / axle counters related details, if proposed Factor in the short circuit currents appropriately in S&TC design Cable support infrastructure in viaducts and tunnels for respective cables Return current cable connections from running rails Insulated rail joint related requirements Signal locations 	Shall interface, provide necessary inputs, share information and seek information from S&TC Contractor: <ul style="list-style-type: none"> EMC/EMI study related (S&TC cable location etc.) SCADA system design at OCC (ergonomic design, compatibility with S&TC system, visual control panel harmony etc.) Earthing & bonding plan (lead role) – to factor in track-circuit / axle counter (if used by S&TC) requirements appropriately Share normal and short circuit current levels in 3rd rail Cable support infrastructure in viaducts and tunnels for respective cables Return current cable connections from running rails Insulated rail joint related requirements Signal locations
2	Third Rail and Trackside Signal designs	Shall provide chainages of signal posts and stopping marker boards at stations for necessary interface with Traction	Shall incorporate in traction third rail arrangements as well as routing of HT and DC cables along the viaduct considering the S&TC requirements

Item No.	Item Description	S&TC Contractors	PST Contractor
		Shall ensure that signals are mounted in appropriate locations	
3	Electrical Interface	Shall furnish the Traction Power Contractor(s) specific requirement for Signalling system	Shall advise the S&TC Contractor of the normal and worst short circuit current levels
4	Bridgeable, non-bridgeable gaps and third rail ramps types at Crossover locations	Shall design the Signalling System such that no train or a part of a train stops within the non-bridgeable gaps during normal operations in various modes and appropriately consider the information received from traction in ATC design.	Shall provide the length and location of all traction, bridgeable, non-bridgeable gaps and types and locations of third rail ramps
5	Activation of ESP	Information of ESP Activation forwarded to Traction and Power supply System	Switching off of Traction Power supply through Emergency Trip System after receiving the ESP Signal from Signalling System
C&I Stage			
6	Third Rail and Trackside Signal designs	<ul style="list-style-type: none"> Shall ensure that signals are mounted in appropriate locations Shall co-ordinate for ensuring the minimum safe distance between any Signalling field installation and the live third rail contact point for the purpose of personnel safety apart from EMI / EMC considerations. Similar minimum safe distances between power distributor line and Signalling/ communication cables/wires within the station premises shall also be ensured by both the Contractors. 	<ul style="list-style-type: none"> Shall provide the location of all Third Rail positions inclusive of bridgeable, non-bridgeable gaps in the Depot and Main line Shall co-ordinate for ensuring the minimum safe distance between any Signalling field installation and the live third rail contact point for the purpose of personnel safety apart from EMI / EMC considerations. Similar minimum safe distances between power distributor line and Signalling/ communication cables/wires within the station premises shall also be ensured by both the Contractors.
7	Electrical Interface	<ul style="list-style-type: none"> Shall agree on the final location of cross bonds and other rail connections related to traction return current Shall furnish the Traction Power Contractor(s) specific requirement for Signalling system 	<ul style="list-style-type: none"> Shall agree on the final location of cross bonds and other rail connections related to traction return current Shall supply, install and terminate traction bonding cables, if required additionally, at appropriate intervals, which shall be coordinated with the Signalling Contractor to ensure the balanced & unobstructed flow of traction return current. Shall supply and install the traction return cables including all accessories required for fixing, connection and terminations

Item No.	Item Description	S&TC Contractors	PST Contractor
8	Bridgeable, non-bridgeable gaps and third rail ramps types at Crossover locations	Shall design the Signalling System such that no train or a part of a train stops within the non-bridgeable sections during normal operations in various modes and appropriately consider the information received from traction in ATC design.	Shall share the third rail installation plan for main line and depot clearly marking bridgeable and non-bridgeable gaps, ramps, power feed, power sectioning, etc. shall also be shared along with speed restrictions applicable if any
9	Functional Interface	<ul style="list-style-type: none"> Shall ensure that the Signalling and Train Control System makes allowance for the settings as received from traction power Contractor when planning for simultaneous start-up of several trains The Contractors shall ensure that there is no degradation with respect to the performance requirement as specified in the respective Specifications 	<ul style="list-style-type: none"> Shall provide the Third Rail feeder circuit rating, the protection tripping setting, the third rail conductor current carrying capacity, Transient & surge protection and the protection relay setting The Contractors shall ensure that there is no degradation with respect to the performance requirement as specified in the respective Specifications
10	Electromagnetic Compatibility	<ul style="list-style-type: none"> The Traction Power and Signalling Contractors shall perform a study and develop the Electromagnetic Compatibility Management Plans using such data as the emission characteristics, susceptibility levels, filter characteristics, physical layout and construction of their equipment, taking into consideration variation in component characteristics with frequencies. The study shall demonstrate compatibility or highlight areas of potential problems with a view to implement remedial measures in time to achieve compatibility. The Traction Power and Signalling Contractors shall co-ordinate for any information concerning EMI / EMC for the Third Rail & other structures. The Contractors shall interface to develop a test plan detailing how the electromagnetic compatibility of the Third Rail Traction System and the Signalling and Train control System will be verified, taking into consideration the study conducted. 	Same joint responsibility as for S&TC
11	Earthing of outdoor Signalling equipment	<ul style="list-style-type: none"> Shall provide earthing for all outdoor Signalling gears by connecting to BEC in mainline. Shall supply and install dedicated earth conductor for the trackside Signalling equipment and connect the same with BEC in depot area. 	<ul style="list-style-type: none"> Shall supply and lay Bare Earth Conductor (BEC) along the viaduct and extend earth in mainline. Shall facilitate for connection of dedicated earth conductor at depot / mainline boundary.

Item No.	Item Description	S&TC Contractors	PST Contractor
12	Locations of Axle counter	Signalling Contractor shall share the details of Axle counter locations to the Traction Contractor.	The Traction Contractor shall consider the location of Axle counter while installing Traction equipment.
13	Bonding, Earthing and Cross Bonds	The Signalling contractor shall interface with Traction Contractor.	Traction Contractor shall design Bonding, Earthing and cross bond plans to suit Axle counter details furnished by Signalling Contractor
14	Electrical Clearances	The Signalling contractor shall co-ordinate with Traction Contractor to ensure minimum safe clearances between any Signalling field installations and the live third rail part.	Traction will provide Layout Plans of Third rail to the Signalling contractor.
15	Power Supply Protection System and trip settings	The Signalling contractor shall ensure Signalling and Train Control Systems are designed suitably.	Traction will advise to the Signalling contractor the protection relay settings.
16	CBTC	The Signalling contractor shall advise Traction, the details of the CBTC system proposed to be adopted and also list out special steps, if any, required to be taken on the Power side.	Traction Contractor shall interface with the Signalling Contractor and shall consider special steps, if any, to be adopted by Traction Contractor
17	Power supply and Traction/ SCADA management,	The S&TC Contractor shall interface with Third Rail/ Power SCADA to obtain the status of Third Rail energization status for generation of alarms at OCC & minimizing the disruption to UTO trains based on the receiving inputs.	Provide interface & protocol details for transferring the information about no power zone and Third rail power shut down on running lines on real time basis to S&TC System
18	SCADA	Design of OCC	The PST Contractor shall co-ordinate with the S&TC Contractor for the finalizing the ergonomic design of OCC
19	Activation of ESP	Information of ESP Activation forwarded to Traction and Power supply System	Switching off of Traction Power supply through Emergency Trip System after receiving the ESP Signal from Signalling System
T&C Stage			
20	IRJ	Shall lead testing / efficiency of IRJ	Shall coordinate as needed
21	Protection setting	Shall coordinate as needed	Shall lead testing as required
22	Return cables, Earthing & bonding	Shall coordinate as needed	Shall lead testing as required
23	EMC/EMI testing	Shall lead EMC/EMI testing The Contractors shall also jointly develop a test plan detailing how the electromagnetic compatibility of Traction, S&TC and Telecom systems including Radio systems will be verified. The Contractors shall work together to assure that all electronic and electrical	Shall associate and provide relevant inputs

Item No.	Item Description	S&TC Contractors	PST Contractor
		equipment on the rolling stock works properly without interfering with S&TC or Telecom sub-systems.	
24	Operating Modes and Principle Document (OMPD)	The S&TC Contractor as a Lead Contractor shall prepare a comprehensive Operating Modes and Principle Document (OMPD). The document shall establish the principles related to system and interface design under normal, degraded and emergency modes of operation. For each operating principle the document shall describe the scenario, action to be taken by operator and system in a structured process flow chart.	The PST Contractor will also assist the S&TC Contractor in preparation of the documents.
25	Activation of ESP/ETS	Joint test of ESP/ETS Activation and Traction and Power supply System status respectively	Joint test of ESP/ETS Activation and Traction and Power supply System status respectively
	Maintenance stage		
26	Nil		

11.14 INTERFACES WITH PSD/PSG CONTRACTOR

11.14.1 Scope of Interface & Division of Responsibilities

- 11.14.1.1 The S&TC Contractor and PSD Contractor shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:
- 11.14.1.2 The train control system shall detect the status of PSD /PSG continuously and provide commands for the opening and closing of the PSDs/PSGs.
- 11.14.1.3 In the event of a platform screen becoming unlocked when no train is located within the platform, emergency braking (EB) shall be initiated for trains within a predefined section approaching the station. A local manual reset by authorized personnel shall be required prior to the restoration of the operation.
- 11.14.1.4 A train stationary at station platform shall not be permitted to move automatically until all platform screen doors relevant to the platform at which the train is located are proven to be correctly closed and locked.
- 11.14.1.5 The ATP shall monitor the train and platform screen door in order to authorize their opening only if the following conditions are met:
- Train speed is zero
 - Vehicle and platform screen doors are properly aligned within the allowable tolerances
 - The brakes have been properly applied (service brake or emergency brake)
 - The propulsion system is disabled
 - PSD /PSG doors proven closed and locked

- 11.14.1.6 The S&TC and PSD/PSG Contractors shall interface for the exchange of required signals in a failsafe manner. The level, duration and timing of the signal shall be interfaced between the S&TC and PSD/PSG Contractor and put up for approval of Employer's Engineer.
- 11.14.1.7 The facilities for controlling an emergency opening of platform screen doors either from the OCC, from the track side or from the platform side shall require, the minimum conditions to be fulfilled:
- Local command from station master control room
 - Predefined track sections (covering, for both directions, approaching trains and trains which have started but not yet cleared the platform) around the platform screen door have been blocked.
 - Trains in predefined sections are at zero speed, and the service brake is applied.
- 11.14.1.8 The S&TC Contractor and PSD/PSG Contractor shall perform a comprehensive interface hazard analysis in accordance with the relevant system safety and assurance standards.
- 11.14.1.9 The PSD/PSG Contractor shall forward all alarms and events regarding any defective status of the PSD/PSG to the Train Control system viz. door failed to close or open before a preset time after door close or open command is issued, PSD/PSG power supply failure, PSD/PSG system failure, manual override of the opening of the doors and any other alarms and events for troubleshooting & maintenance.
- 11.14.1.10 Both Contractors shall ensure that the equipment and its associated devices are immune to EMI/RFI and do not cause EMI/RFI problems to other systems.
- 11.14.1.11 Integrated Testing and Commissioning**
Integrated testing and commissioning shall be jointly performed by RS Contractor, S&TC Contractor, Telecom Contractor and PSD/PSG Contractor
- 11.14.1.11.1 Responsibility of PSD/PSG Contractor includes for contribution / preparation of comprehensive System integration testing plan, protocol & procedure and Operating Modes and Principle Document (OMPD).
- 11.14.1.12 Interface with S&TC Contractor for UPS Power Supply**
- 11.14.1.12.1 Three-Phase 415V AC supply from the UPS, to meet the requirement of Telecom, AFC, PSD and S&TC System shall be provided by S&TC Contractor in UPS (S&T) Room. PSD Contractor shall extend the AC Power supply from UPS Rooms to PSD equipment.
- 11.14.1.12.2 PSD Contractor shall work out actual load and circuit requirements for stations and shall submit the design of the AC power distribution systems for each station
- 11.14.1.12.3 PSD Contractor to interface with S&TC Contractor for UPS power requirement for PSD equipment at stations / OCC / BCC / Depot.

Note: Above interface requirements are just indicative and not comprehensive. The Contractors should follow the best practices of metro for the interface/integration during project execution

Item No.	Item Description	S&TC Contractors	PG/PSD Contractor
Design Stage			
1	PSD/PG System Design	Shall lead the process and interface with PG/PSD Contractor appropriately	PSD/PG Contractor shall interface with S&TC Contractor for the exchange of required signals in a failsafe manner for the controlling of PSD/PG. The level, duration and timing of the signal shall be decided mutually.
2	Equipment Room layout in SER and SMR	Coordinate PSD/PG Contractor to install equipment in SER. False flooring will be provided by Signalling Contractor.	Mark location of PSD/PG equipment in SER and install pedestal for PSD/PG equipment
C&I Stage			
3	PSD/PG System Implementation stage	The S&TC system shall detect the status of PSD/PG continuously and give command for opening and closing of PSD/PG	The PSD Contractor shall interface with S&TC Contractor to continuously monitor and control the PSD/PG by S&TC System
4	As above	The S&TC system shall detect the unlocked status of PSD/PG and apply Emergency Brake for all trains in the predefined sections	Any unlocked status of door during dwell time shall be exchanged with S&TC system to initiate Emergency Brake application for trains in that section of line
5	As above	Shall ensure that Train Door closing authorization will not be initiated till all PSD/PG doors are closed	Shall exchange all PSD/PG gate close status to the S&TC system
6	As above	Shall ensure that Train doors and platform screen doors/gates are properly aligned within the allowable tolerances, the brakes have been properly applied (service brake or emergency brake), propulsion system is disabled and Train speed is zero	Shall ensure that PSD/PG door opening will not be initiated till platform screen doors/gates are properly aligned Train doors within the allowable tolerances
7	As above	The S&TC Contractor shall interface for exchange of signals and develop protocol for proper working of Platform Screen Door/Gates (PSD/PG)	The PSD/PG Contractor shall exchange necessary signals with the S&TC Contractor for proper functioning of Train Door
8	As above	Rolling stock, S&TC and PSD/PG Contractors shall exchange the defective/Isolated train door and PSD/PG information so that if a Particular train door is defective/isolated, the corresponding PSD/PG shall not open and vice versa	Same responsibility as that of interfacing Contractor
9	As above	The PSD/PG and S&TC Contractor shall ensure that facilities for controlling the emergency opening of platform screen doors/Gates (from OCC/BCC, from Trackside or Platform side, from SCR) shall exist in case of any emergency or train blockage in platform area	Same responsibility as that of interfacing Contractor
10	As above	S&TC Contractor and PSD/PG Contractor shall carry out interface hazard analysis and power requirements and take corrective measures to mitigate the same	Same responsibility as that of interfacing Contractor

Item No.	Item Description	S&TC Contractors	PG/PSD Contractor
11	As above	The PSD/PG System shall forward alarms & events regarding defective status of PSD/PG to S&TC system viz. door failed to close before a preset time after door close command is issued, PSD/PG power supply failure, PSD/PG system failure, other alarms and events for troubleshooting & maintenance	S&TC System shall initiate action accordingly as per predefined failure management plan
12	As above	PSD/PG and S&TC Contractors shall ensure that the equipment and its associated devices are immune to EMI/RFI and do not cause EMI/RFI problems to other systems	Same responsibility as that of interfacing Contractor
	T&C Stage		
13	System testing	Shall lead the system testing for all the relevant items	Shall participate
	O&M Stage		
14	Nil		

11.15 INTERFACES WITH AFC CONTRACTOR

11.15.1 The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item no.	Subject	Signalling & Train Control (S&TC) Contractor	AFC Contractor
	Design stage		
1	Provision of UPS for AFC system	Shall coordinate with AFC Contractor for power requirements for sizing of the UPS for: - i) OCC ii) Stations	The AFC Contractor shall furnish load requirements to S&TC Contractor for: - i) OCC ii) Stations
	C&I Stage		
2	Provision of UPS for AFC system	Shall coordinate with AFC Contractor for power requirements and arrange to provide the required capacity in the UPS system with suitable termination points in the UPS room. Shall also provide UPS power to AFC workstation, printer etc. in SCR.	The AFC Contractor shall coordinate and install their own power distribution cubicle including the MCB's there in and further install Power Cables to their equipment.
3	Furniture	Shall coordinate with AFC Contractor for requirement of furniture in SCR. Supply and provide furniture.	Shall confirm furniture requirements to Signalling Contractor for SCR.
	T&C stage		

Item no.	Subject	Signalling & Train Control (S&TC) Contractor	AFC Contractor
4	UPS supply	Shall jointly test power service to AFC Electrical cabinet from S&T UPS	Shall jointly test power service to AFC electrical cabinet from S&T UPS
Maintenance stage			
5		Nil	Nil

11.16 INTERFACES WITH TRACK CONTRACTOR

11.16.1 The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item no.	Subject	S&TC Contractor	Track Contractor(s)
Design Stage			
1	Various interfaces	Shall interface, provide necessary inputs, share information and seek information from TRW Contractor	Shall interface, provide necessary inputs, share information and seek information from S&TC Contractor: <ul style="list-style-type: none"> Share electrical properties of track assemblies Share as-finalized alignment with all requisite details Obtain cable crossing information through plinth Share track layout details for accommodating trains including safe margin Any other requisite interface details
2	Marking of Axle counter	<ul style="list-style-type: none"> Mark the Axle counter area as per approved design. Shall co-ordinate with Track Contractor for fixing of the track side Signalling equipment. 	<ul style="list-style-type: none"> Design the track plinth structures in the Axle counter area suitable for their requirements. Construct any structures below the rail in Axle counter area to suit the requirements of the Signalling Contractor
C&I Stage			
3	Electrical properties of track assemblies	Shall furnish the electrical requirements for track circuits / axle counters.	Shall provide the same so as to meet electrical requirements of S&TC Contractor.
4	As planned and As built track alignment & profile plans	Shall incorporate the same in S&TC System design.	Shall provide the same giving the details of curves & gradients and also civil speed restrictions.
5	Turn out assemblies and their mounting & driving arrangements	S&TC Contractor shall supply & install the point machines, leading (1 st) stretcher bar & co-ordinate with Track Contractor(s) for design and installation of	<ul style="list-style-type: none"> Shall supply and install the Turnout assemblies and provide for the mounting arrangements / foundation for point machines including second

Item no.	Subject	S&TC Contractor	Track Contractor(s)
		second drive arrangement. Shall supply locking arrangement for second drive, if required.	drive arrangements (if required). Provide holes on switches for fixing of point machine driving arrangement and stretcher bars as necessary. <ul style="list-style-type: none"> Supply second drive arrangements to the Signalling Contractor (if required).
6	Insulated glued joints/ Insulated fish Plated joint	Shall furnish the requirement and locations of all insulated glued joints/ insulated fish plated joints to Track Contractor(s).	Shall supply and install the insulated glued joints/ Insulated fish plated joint at the designated locations as per requirements of S&TC Contractor.
7	Marking of Axle counters	Mark the Axle counter area as per approved design and submit the requirements for execution.	Design and provide the track plinth structures in the Axle counter location.
8	Scope of Supplies	Signalling Contractor shall supply & install the point machines and co-ordinate with Track Contractor(s) for design and installation.	Shall supply & install all track assemblies & Track fasteners, turnouts, all stretcher bars, second drive for point machines. The design of second drive arrangement (as applicable) shall be coordinated and interfaced with Signalling Contractor to ensure full compatibility.
9	Track crossing of Cables	Shall provide designated location marking for track Crossings and supply pipes (not greater than 100 mm) and support.	Shall provide cut-outs/embed the pipes in the track plinth on ballast less track/lay pipes in ballasted track, at designated locations in coordination with Signalling Contractor.
10	Installation of trackside equipment, signal posts.	Shall furnish the final sizes of trackside equipment's and co-ordinate with Track Contractor(s) to ensure the compliance of schedule of dimensions.	Shall co-ordinate with S&TC Contractor to ensure the compliance of schedule of dimensions.
11	Track connections	Shall Supply & Install Axle counter fixture and point machine connection in track with the co-ordination of track work Contractor.	Shall co-ordinate with Signalling Contractor for Axle counter fixtures and point machine connections with track. Shall provide slits (cuts) in up stands for track connections wherever required.
12	Installation of points operation mechanism	Shall check the proper gauge, housing of points and operating of switches and all other items necessary from signalling point of view, S&TC Contractor shall make necessary adjustment to points operating mechanism as required by track Contractor(s) at the time of track parameters correction and tamping of ballasted turnouts.	Shall provide proper gauge, housing of points and opening of switches and carry out all other works as required to make the point suitable for installation of point machine by S&TC Contractor.
13	Prototype integration of point assembly and point machine mechanism	Shall coordinate and supply required setup to Track Contractor/ Turnout Supplier to arrange for factory testing of the prototype including joint testing.	Shall arrange for factory testing the prototype duly interfacing with S&TC Contractor including joint testing.

Item no.	Subject	S&TC Contractor	Track Contractor(s)
14	Overrun protection	Determine the track length required at all terminus, sidings, turn back facilities and stabling tracks for accommodating the trains and advise Track Contractor	Provide sufficient track length for accommodating the trains as required by S&TC Contractor.
15	Buffer Stop Signals	Shall advise the location of Buffer Stops to be provided on the track and shall co-ordinate with Track Contractors for installation of Buffer Stop Signals	Shall supply and install the buffer stops at terminal stations and other locations in co-ordination with S&TC Contractor
T&C Stage			
16	Testing of points and crossings	Jointly test with track Contractor(s) during installation and while commissioning of point machines and during integrated testing & commissioning.	Jointly test with S&TC Contractor during installation and while commissioning of point machines and during integrated testing & commissioning and rectify all defects pertaining to track, if any, identified during testing and commissioning of points.
17	Testing of rail-to-rail, rail to sleeper and insulated joints	Testing of glued IRJ jointly before installation and install IRJ as per the requirement of S&TC Contractor.	Testing of Insulated Glued Joint before installation. Install Insulation Rail Joints in track as per the requirement of S&TC Contractor
Maintenance Stage			
18	Nil		

11.17 INTERFACE WITH TVS CONTRACTOR

11.17.17 The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	S&TC Contractor	TVS Contractor
Design Stage			
1	Track way and tunnel ventilation control according to signaling system	Control signal and communication standard via Ethernet TCP/IP protocol. Locations of stopping trains at congestion and emergency sent to OCC has to be provided	Shall integrate the data of Location of Trains into TVS SCADA
2	Ventilation shaft location	Shall reflect the rule "one train for ventilation section" and thus coordinates for ventilation shaft location and ensure that at any given point of time there is only one train in a single ventilation zone during congestion / emergency scenarios	Shall clearly define the ventilation zones and the no. of trains in one ventilation zone at any given point of time during congestion / emergency scenario

Item No.	Subject	S&TC Contractor	TVS Contractor
3	TVS SCADA cable interface	Shall coordinate the location of TER room for termination of TVS SCADA cables into Ethernet Switch. Cable from TVS Ethernet switch at station TER room to S&TC equipment (Ethernet switch port).	Provision of TVS Ethernet switch at station TER room for termination of TVS SCADA cables from TVS control panels in stations
4	OCC HMI	Shall accommodate the space for the HMI of TVS SCADA and cabling of TVS at OCC theatre duly taking this into account the ergonomics study	Shall provide the necessary dimensions for the HMI of TVS SCADA and cabling of TVS at OCC theatre
5	IBP Room at OCC	Shall provide the space for IBP in a dedicated room at OCC close to OCC theater	Shall co-ordinate and provide the requirements of room dimensions and IBP details
C&I Stage			
6	All relevant issues	Shall coordinate appropriately to ensure the agreed requirements are implemented	Shall construct and install the TVS system as per the agreed designs
7	TVS SCADA interface	At the OCC, shall install suitable interfacing arrangements at the TVS SCADA end and provide cable connection up to the interface device of TVS SCADA system for exchange of high-level alarms	At the OCC, shall install and cabling the interface device to TVS SCADA system end for exchange of high-level alarms
8	Furniture in OCC	Shall provide the necessary furniture's in the OCC theatre and Station level to accommodate the TVS SCADA HMI's	Shall monitor
9	Interface of S&TC System with Tunnel Ventilation (TVS) System	<ul style="list-style-type: none"> The S&TC system shall prevent any train from leaving a station until the train ahead has arrived at the ventilation zone/section. It shall be possible for the controller from OCC to remove and restore the above restriction section by section The S&TC System shall provide an alarm to the SCADA system controlling the Tunnel Ventilation System 	TVS Contractor shall appropriately coordinate with S&TC Contractor to achieve the requisite functionalities
T&C Stage			
10	System functional testing	Shall attend the joint test and validate the results	<p>Shall jointly test the control and monitoring arrangements of TVS between the OCC and different UG stations</p> <p>Shall jointly test the real time data of the train location</p>
O&M Stage			
11	Procedure	Prepare the joint maintenance procedures and periodicity of joint inspection regarding the working of	Validate the joint maintenance procedure document prepared

Item No.	Subject	S&TC Contractor	TVS Contractor
		inter station data connectivity through CBN, Inter station data connectivity through the CBN, intra site LAN network and the monitoring of high levels alarms of TVS SCADA system	

11.1 INTERFACE WITH ECS CONTRACTOR

11.18.1 The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	S&TC Contractor	ECS Contractor
	Design Stage		
1	Equipment heat load	Provide S&TC equipment heat loads	Design of ECS provision in S&TC room
2	Layout design	Coordinate with ECS on location of FCUs, piping and ductworks in S&TC room	Prepare design and location of FCUs, piping and ductworks in S&TC room
3	ECS system design input data	Shall furnish the details of equipment heat generation load, number of persons and Ventilation or Air conditioning requirement from S&T system rooms such as SCR, SMR, S&T UPS Room and SER to design the ECS system in all underground stations	Shall take into account the details of equipment heat generation load, number of persons and Ventilation or Air conditioning requirement from S&TC system rooms such as SCR, SMR, S&T UPS Room and SER to design the ECS system in all underground stations
4	SCR & OCC room layout	Shall accommodate the space for ECS SCADA system, IBP and cabling of ECS system at SCR& OCC	Shall provide the necessary dimensions for ECS SCADA system, IBP and cabling of ECS system at SCR& OCC
	C&I Stage		
5	ECS SCADA (BMS) installation	Shall monitor and Co-ordinate	Shall install ECS SCADA (BMS) system and IBP at SCR including cabling of ECS system
6	ECS installation	Shall monitor	Shall install the ECS system in SCR, SER, CER and TC SMR, S&T UPS Room
7	SCR furniture	Shall provide the necessary furniture's in the SCR to accommodate ECS SCADA (BMS) system	Shall monitor
	T&C Stage		
8	System testing	<ul style="list-style-type: none"> Shall attend and verify the ECS parameters such as temperature and relative humidity in S&TC system rooms at all underground stations Shall attend the joint test and validate the results 	<ul style="list-style-type: none"> Shall conduct joint testing on ECS system in S&TC system rooms at all underground stations Shall jointly test the monitoring arrangements of ECS system between the OCC and different stations, through the TVS SCADA using CBN

Item No.	Subject	S&TC Contractor	ECS Contractor
	O&M Stage		
9	Procedure	Finalize the joint maintenance procedures and periodically of joint inspection between S&TC and ECS system and include the same in the S&TC maintenance manual	Shall validate the joint maintenance procedures and test plans prepared by S&TC Contractor

11.19 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 5.1.11 above](#) shall apply as relevant to the context

11.20 INTERFACE WITH AUTO WASH PLANT CONTRACTORS

11.20.1 Introduction – General

- a. This Specification covers the interface requirements between Signalling & Train Control Contract 10S&T-DM and Train Auto wash plant system Contract(s).
- b. This document shall be read in conjunction with the relevant paragraphs of the General Specification. The Contractors shall ensure all requirements of the General Specification and Technical Specification pertaining to interfaces are fully resolved and implemented.
- c. In the event of a conflict between any Technical Specification and this Specification, the requirements of this Interface Specification shall prevail.

11.20.2 Interface Responsibilities

- a. The responsibility for specification and provision of the requirements for the Works that interface with Designated Contractors' equipment is **tabulated in corresponding section of the document.**
- b. The requirements specified herein are by no means exhaustive and it remains the Contractors' responsibilities to develop and execute jointly an Interface Plan after the commencement of the works and throughout the execution of works, to ensure that:
 - i. All interfacing issues between the two Contracts are satisfactorily resolved;
 - ii. Supply, installation and testing of equipment and software are fully co-ordinated;
 - iii. All equipment supplied under the Contracts is fully compatible with each other, whilst meeting the requirements of the respective Specifications.
 - iv. All the construction tolerances at the interface shall meet the requirements of the respective specifications relating to the interface points
 - v. Interface contractors shall mutually respect each other's project timelines with respect to the interface requirements.
 - vi. Interface contractors shall finalize their respective interface equipment only after clear agreement on interface requirements with the other designated contractors.

- vii. Interface contractors shall ensure that in any case, no equipment of their system shall be put into production or installation without meeting the interface requirements spelt out in this Appendix or in the Technical Specification.
- viii. Test procedures, troubleshooting manuals and any other documentation shall be updated with technical details from of each contractor and shall be submitted to BMRCL.

11.20.3 Interface Management

- a. Signalling and Train Control System Contractor shall be the Lead Contractor. The Lead Contractor will be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors all the required interfaces and interface design documents and interface progress reports for submission to Engineer / BMRCL for acceptance. The Lead Contractor will also prepare and issue all interface meeting of minutes within 3 days of the meeting and provide bi-weekly interface progress reports to all the participating contractors for information. Later, forwarding of issued minutes of meeting and bi-weekly interface progress reports to concerned Contractors shall be Lead Contractor's responsibility.
- b. Train Auto wash plant Contractor will be the Participating Contractor on this interface. The Participating Contractors shall collaborate fully with the Lead Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.
- c. All Participating Contractors shall ensure that copy of the Interface design documents are submitted to Engineer / BMRCL.
- d. The costs for all interface design and testing works shall be deemed to be included in the sum of respective contracts regardless of the actual extent of effort required or expended by the Contractor.
- e. The Contractors shall be fully responsible for the management and control of their respective subcontractors in relation to all interfacing activities carried out under the Contract.
- f. Wherever requirements of OCC are mentioned in this chapter, the same shall mean to be implemented for both Operations Control Centre (OCC) and Backup Control Centre (BOCC).
- g. S&TC Contractor and the Train Auto wash plant Contractor shall prepare a joint compliance matrix for this interface specification and relevant clauses of the Metro Railway General Rules 2020, especially that of UTO operation (GoA 4 operation) related and submit to BMRCL for review.

11.20.4 Interface Requirements

- a. The Signalling & Train Control Contractor and the Wash plant Contractor shall interface to ensure that the precise Wash plant locations for front rear washing etc. are communicated by the Wash plant Contractor to the Signalling & Train Control Contractor to identify the Train stopping points for the washing so that the same can be incorporated in the design. The stopping accuracy requirement for station platform shall be applicable to the stopping in the wash plant also (+250mm window for 99.98% of the stopping: Jog mode to align; if not aligned to docking window in initial stop)
- b. The Signalling & Train Control Contractor and the wash plant Contractor shall interface to ensure that the sensors of Signalling system (Balise, Beacon, Loop, Detection Points etc) and the sensors of the wash plant are not conflicting/infringing to each other. A joint drawing shall be prepared and submitted to BMRCL in which all the sensors from both Contractors' are shown.
- c. The control panel of the wash plant shall be incorporated in the DCC layout design by the Signalling & Train Control Contractor. The wash plant Contractor shall provide the details of the same.

- d. Facility shall be provided for operating trains in full civil speed through the wash plant if the trains are not designated to be washed.
- e. In case the wash plant is in the maintenance block state, the signalling system shall reroute all trains through the by-pass path, if track layout permits.
The Signalling & Train Control Contractor shall propose the bypass facility and its implementation to Engineer for approval.
- f. Wash plant system-Signalling Interface communication interface
 - i. The Availability status of the wash plant, maintenance block status etc. shall be communicated in real time to the Signalling system.
 - ii. The signalling system shall communicate the upcoming washing assignment to the wash plant system and the system shall prepare for the washing.
 - iii. The two-way information in various stages of the washing shall be communicated by signalling and wash plant system in parallel with each other to facilitate a GoA4 mode of washing with no manual intervention from the train or from the control room side. It shall also be possible to operate the wash plant with a train Operator inside.
 - iv. The Signalling & Train Control Contractor and the Wash plant contractor shall interface to ensure that activation of the wash plant emergency stop plunger (ESP) of the signalling system will initiate immediate Emergency brake in the train as well as immediate stoppage of the wash plant. The resetting of ESP shall cause the graceful resumption of the washing from the stage where it was suspended.
 - v. The Signalling & Train Control Contractor shall provide interface panel/panels in the wash plant room adjacent to the wash plant. All vital and non-vital communication shall be directed through this panel. The wiring from this panel to the wash plant equipment is in the scope of wash plant contractor.

11.20.5 INTERFACE- Division of Responsibility

Signalling & Train Control Contractor shall coordinate with Train Auto Wash Plant Contractor/s in order to achieve the functional and operational requirements of the system.

The roles and activities of the Contractors shall broadly include minimum but not limited to those mentioned in table below. Apart from the below table, the contractors shall also adhere to all the Interface specifications (as above) and the GS and TS requirements.

SN.	ST/WP Item	STC Contractor	Wash plant contractor
01	Space proofing for sensors	<ul style="list-style-type: none"> Shall coordinate and provide inputs 	<ul style="list-style-type: none"> Shall coordinate and prepare.
02	Locations of stopping	<ul style="list-style-type: none"> Shall incorporate the details in the design 	<ul style="list-style-type: none"> Shall provide the inputs
03	Details of interface	<ul style="list-style-type: none"> Shall design the panel, its location in the plant room etc 	<ul style="list-style-type: none"> Shall interface and provide inputs

	panels		
04	Details of control panel in DCC	<ul style="list-style-type: none">• Shall incorporate in the overall design of DCC	<ul style="list-style-type: none">• Shall interface and provide inputs
05	Communication between the systems	<ul style="list-style-type: none">• Shall design the interface and advise the network parameters and communication protocols	<ul style="list-style-type: none">• Shall provide and receive the information in desired format and comply the network parameters and communication protocols.
06	Joint Testing plan	<ul style="list-style-type: none">• Shall coordinate to prepare the test document and participate in the test.• Joint testing plan shall be prepared and conducted to validate the design coordination to check the following as a minimum to test the functional requirements mentioned in previous sections of the document.	<ul style="list-style-type: none">• Shall provide inputs in the test plan and shall attend the test

CHAPTER 12

12.0 ROLLING STOCK INTERFACES

12.1.1 INTERFACES WITH ELEVATED CIVIL CONTRACTORS

Refer to [Para 2.1.6 above](#)

12.1.2 INTERFACES WITH UG CIVIL CONTRACTORS

Refer to [Para 3.1.6 above](#)

12.1.3 INTERFACES WITH DEPOT CIVIL CONTRACTORS

Refer to [Para 4.1.6 above](#)

12.1.4 INTERFACES WITH DEPOT E&M CONTRACTORS

Refer to [Para 7.1.4 above](#)

12.1.5 INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS

Refer to [Para 10.1.4 above](#)

12.1.6 INTERFACES WITH S&TC CONTRACTOR

Refer to [Para 11.1.10 above](#) for Extension Lines and [Para 11.1.11 above](#) for New Lines

12.1.7 INTERFACES WITH TELECOM CONTRACTOR (EXTENSION CORRIDORS)

Details of Contractors

- 12.1.7.1 The Telecommunication and Rolling Stock Contractors for the Phase-1 Extensions shall ensure complete integration of their respective equipment with the Interface requirements among these systems and also ensure that any new equipment is fully backward compatible with the existing system and with equipment which has already been identified and finalized for the relevant extension lines / sections. For example, the Rolling Stock Contractor shall ensure that the trains designated for operations on Line-1 and Line-2 including four extensions are compatible with the Telecommunication system as provided under the Phase-1 Contract, similarly the Telecommunication Contractor shall ensure compatibility with train-sets supplied under Phase-1 project.
- 12.1.7.2 It is expected that the Telecommunication and Rolling Stock Contractors for the Phase-1 Extensions shall adopt the existing interfaces among these systems for Line 1 and Line 2. The interface to be followed with Rolling Stock Contractor will be same as the Design Interface Document of Phase-I.
- 12.1.7.3 While the existing interface requirements as finalized, generally meet the requirements described in the following clauses, Detailed Interface Documents have already been developed for these interfaces for Line 1 and 2, which shall be used as baseline documents. The Contractors shall take the advancement in technology, communication protocols, physical media of transmission and operational requirements for new trains into consideration and appropriately provide interfacing requirements.

Train Operating Modes

- 12.1.7.4 The train-borne Automatic Train Control (ATC) system will consist of Automatic Train Operation (ATO) and Automatic Train Protection (ATP) systems on Line-1 and Line-2 including extensions.

- 12.1.7.5 The Rolling Stock required for Line-1 and Line-2 including extensions shall be fitted with ATP/ATO system.
- 12.1.7.6 There will be on-board Radio and BBRS communication systems. The supply/delivery of Train Radio System for new trains shall be responsibility of the Contractor for Telecommunication for the respective extension lines, and shall be required to liaise closely with the Rolling Stock Contractor, in regard to installation, testing and commissioning of the Telecommunication equipment.

TETRA Radio System

The TETRA Radio System shall provide a digital, standard radio communications system, conforming to the TETRA standards as defined by ETSI, capable of facilitating system-wide voice and data communication to support the Operation and Maintenance of the BMRCL. The TETRA Radio System (TRS) shall guarantee secure Operational Communications for the OCC, BCC, Train drivers, station staff, depot staff and mobile maintenance personnel. Communication shall be configurable between any of these user groups.

Broad Band Radio System

- 12.1.7.7 The Broad Band Radio System (BBRS) is a Radio based system that shall assure additional Communications needs related with Passengers Services. Its primary objective is to provide a communication interface to the on-board CCTV and simultaneous remote monitoring of these images from OCC, BCC and the security Room.
- 12.1.7.8 The RS Contractor shall log each time the mode is changed using the on-board TCMS (Train Control Management System) equipment.

Interface Requirements between Telecommunication and Rolling Stock Contractors

- 12.1.7.9 The Telecommunication Contractor shall provide the Rolling Stock Contractor with the final list of equipment to be provided on the Rolling Stock. The sizes and weights of the on-board Radio equipment and antennae etc., to be mounted on the Rolling Stock shall also be provided as applicable.
- 12.1.7.10 The Telecommunication Contractor shall deliver to the Rolling Stock Contractor's factory/premises, all train borne equipment, in respect to new trains, and data to enable fitting and testing. The Telecommunication Contractor, with the details provided by the Rolling Stock Contractor, shall ensure that the exterior finish and colours of the respective equipment suitably harmonize with that of the cab and the vicinity.
- 12.1.7.11 The Telecommunication Contractor shall supply all the train radio equipment including the Train Radio Control Panel at the Rolling Stock Contractor's factory for new trains.
- 12.1.7.12 Interfacing wiring for each module provided by the Telecommunication Contractor including the interfacing wiring between the Telecommunications Contractors equipment shall terminate in a quick disconnect robust plug connector suitable for traction applications, with direct cable connection as far as possible. All cable connectors shall be identified within the cubicle using robust cable markers with distinctive colours for identification, for e.g. safety function cables.
- 12.1.7.13 For all relay contact interfaces (if applicable), the Telecommunication Contractor shall provide auto-contact jam detection and contact bounce elimination function to ensure proper operation of the system. Relays for safety functions shall comply with the appropriate internationally accepted standard specification.
- 12.1.7.14 The Telecommunication Contractor shall provide the Rolling Stock Contractor with the number of wires/communication architecture and protocols required between cars of a married pair and between married pairs to transmit signals from one end of the rake to the other end through an electrical jumper.

- 12.1.7.15 Vehicle control circuits shall be developed by the Rolling Stock Contractor. During the design stage, all vehicle control circuits incorporating the identified interfaces shall be provided to the Telecommunication Contractor, as applicable. The Telecommunication Contractor shall provide specific observations on these circuits to the Rolling Stock Contractor. The Rolling Stock Contractor shall suitably incorporate any (if applicable) observations in the design.
- 12.1.7.16 Certain vital and non-vital signals from Telecommunication side shall be monitored by TCMS. These details shall be discussed and finalized during design stage.
- 12.1.7.17 Rolling Stock Contractor shall provide necessary video ports, power points and space for equipment installation in Cab/saloon (saloon is passenger area) for monitoring video camera installed in the saloon area from OCC. For this necessary liaison shall be made with Telecommunication Contractor.
- 12.1.7.18 For New train sets, IP scheme shall be provided by Telecommunication Contractor. The IP scheme shall be jointly agreed and tested by both Contractors.
- 12.1.7.19 Implementation of V-LAN: Telecommunication Contractor shall provide the V-LAN details to Rolling Stock Contractor and same shall be incorporated in interface document and same to be jointly agreed and tested.
- 12.1.7.20 BBRs signal coverage strength shall be provided by Telecommunication Contractor.
- 12.1.7.21 Hot axle box detection system for monitoring of axle box temperature shall be provided by Rolling Stock Contractor. On-board temperature sensors for detecting axle box temperature shall be provided and installed on all axles boxes of 126 cars by Rolling Stock Contractor. The wayside equipment for gathering and processing the data from on-board sensors shall be provided in 3 stations of each line (Line-1 and Line-2) i.e. 6 stations in total on both UP and DOWN track separately by Rolling Stock Contractor. One data base server with workstation in OCC, required software and communication network from way side equipment up to station Telecom Equipment Room (TER) shall be provided by Rolling Stock Contractor. The Telecom Contractor shall provide Ethernet/Fibre Optic channel from station TER (Telecom Equipment Room) to CER (Central Equipment Room) of OCC. Data processing, interface equipment on both ends i.e. at wayside station and OCC shall be the responsibility of Rolling Stock Contractor.

Telecommunication details to be used by RS Contractor

12.1.7.22 The following data shall be provided:

- (i) The maximum power consumed by the Telecommunications Contractor's equipment from the 110V DC supply under all specified operating conditions.
- (ii) The number of train wires required, and the function of each wire/communication architecture and protocols.
- (iii) All control logic outputs.
- (iv) Electrical characteristics of the interconnection cabling and wiring.
- (v) Sensitivity levels, and frequencies, which must be avoided.
- (vi) The specific heat load for air conditioning purposes.
- (vii) The EMC/EMI requirements including the limiting value of photometric current, to obviate interference in the operation of telecommunication equipment; and
- (viii) Details of the provisions required to enable the transference of data from the train to the OCC.

12.1.7.23 Train Radio (TETRA and BBRs) Equipment Cubicles

- (i) The Rolling Stock Contractor shall supply the Train Radio and BBRs equipment cubicle enclosure(s). All supports, braces, mounting holes, cabling apertures, accessories etc. required for mounting the cubicle and its equipment shall be properly coordinated between Telecommunication Contractor and the Rolling Stock Contractor to ensure secure mounting, and access. The cubicle(s) shall be resiliently mounted.

- (ii) To achieve the Train radio functions, the Telecommunication Contractor shall identify any interfacing circuits specifically required for Train Radio operation and liaise with the Rolling Stock Contractor.
- (iii) The Telecommunication Contractor shall respectively identify the voltage free contacts to be provided by the Rolling Stock Contractor, including the number and type of electrical signals required between the Train Radio equipment, BBRS equipment and the equipment provided by the Rolling Stock Contractor. The Contractors shall co-ordinate to agree on levels and protocols for each such signal (for new trains).
- (iv) As a minimum, all electronic equipment to be mounted on rolling stock, including those provided by the Telecommunication Contractor shall comply with IEC 60571: Electronic Equipment used on Rail Vehicles, for design, manufacture and testing, and shall use components purchased against an internationally recognized quality assurance and reliability certification procedure.

12.1.7.24 Antennae

- (i) The Telecommunication Contractor shall identify roof, bogie and under frame-mounted antennae (for train radio and BBRS), and associated disconnection box mounting brackets and location requirements to identify cable and conduit routes required to antennae.
- (ii) The Telecommunication Contractor for their respective scope shall supply the necessary disconnection boxes, terminal blocks, cables and adaptation mounting brackets, flexible conduit assemblies complete with connectors and cables from antennae to the junction boxes.
- (iii) The Rolling Stock Contractor will provide the antenna mounting brackets, conduits, support or clamping arrangements, fixture and accessories to ensure security and reliability.
- (iv) The antenna system shall not contravene the kinematic envelope and fully meet the radio coverage requirements both for normal and reverse directions of train working.
- (v) The Telecommunication Contractor shall furnish the RS Contractor with full mounting details, apertures, fixing holes, etc.

Interface between TCMS and Telecommunication equipment

12.1.7.25 The RS Contractor shall provide an on-board Train Control Management System (TCMS), to log information from the Train radio equipment supplied by the Telecommunication Contractor, in addition to the information shown in the Rolling Stock specification.

12.1.7.26 The signals to be supplied from the TCMS to the equipment of Telecommunication Contractor shall be decided jointly between the two Contractors.

12.1.7.27 The TCMS shall be able to communicate data to OCC, BCC and new depots (Challaghatta, Anjanapura and Whitefield) and existing depot augmentation at Peenya depot using the data link supplied by the Telecommunication Contractor. The data shall contain identified train alarms. The Rolling Stock and Telecommunication Contractor shall interface to make the data available to its destination in OCC/BCC.

Power supply and earthing arrangements

12.1.7.28 The Rolling Stock Contractor shall provide independent 110 V DC power supply circuits/Power Supply requirement to Train Radio equipment as per interface document including positive and negative poles. Both Contractors shall co-ordinate to agree the power supply voltages and arrangements.

12.1.7.29 The Rolling Stock Contractor shall provide dedicated earthing arrangements for the train borne Radio equipment. The Telecommunication Contractor shall specify the earth impedance required.

12.1.7.30 The power supply cable between the train power supply and the Radio train borne power equipment shall be segregated, as short as possible and directly connected to the supply without any intermediate connection.

Telecommunications

- 12.1.7.31 The Telecommunication Contractor shall furnish the Rolling Stock Contractor with the interface required between the train radio system and the on-train public address system to allow on-board announcements to be made from the OCC. The interface shall provide the necessary means to enable OCC to initiate triggering of real time announcement or pre-recorded messages in the on-train public address system.
- 12.1.7.32 The complete on-train public address system, and interface hardware, including the transmission link, and a communication panel shall be furnished by the Rolling Stock Contractor. Levels and protocols shall be agreed between the two Contractors.
- 12.1.7.33 The Rolling Stock Contractor shall provide Train ID to train radio through TCMS-Train Radio interface.
- 12.1.7.34 The Telecommunication Contractor shall furnish the Rolling Stock Contractor with the interface required between the train radio system and the TCMS for recording the initiation, termination, and success or failure of emergency calls initiated by the train driver and/or OCC on the radio. The hardware interface shall be furnished and installed by the Rolling Stock Contractor. Levels and protocols shall be agreed between the two Contractors.
- 12.1.7.35 The Telecommunication Contractor shall furnish/allocate IP address details for Camera, NVR, POE switches and other IP devices inside the train.
- 12.1.7.36 Train video of saloon area to be monitored from the OCC through BBRS. Levels and protocols shall be agreed between the two Contractors.

Factory Installation and Testing

- 12.1.7.37 All the special equipment associated with the train borne Radio system, including the interface cables/wires between the Train Radio equipment shall be designed and supplied by the Telecommunication Contractor to the RS Contractor's premises. Each Contractor shall be aware of the locations of manufacturing plants, which could concurrently be manufacturing cars.
- 12.1.7.38 The Telecommunication Contractor shall be responsible for providing all data and training of Rolling Stock Contractor's staff in all aspects of Telecommunication equipment installation and testing where applicable. The first set of Train Radio equipment shall be installed by Rolling Stock Contractor, under the supervision of the Telecommunications Contractor's Representatives.
- 12.1.7.39 The Rolling Stock Contractor will be responsible for installing of wiring and equipment, and its testing on each car to the functioning standard agreed with the Telecommunication Contractor.
- 12.1.7.40 Testing of each car shall comply with the accepted international standards agreed between the two Contractors as agreed with the Engineer. Initial Integration tests (static and dynamic) shall be done at the Rolling Stock factory and carried out by the test personnel of both Contractors jointly. Further main line integration tests will required to be carried out to ensure all train control functions between OCC and Train which will be required to be done jointly by the Rolling Stock and Telecommunication Contractors on site in Bangalore. The test certificate subsequently shall be issued jointly by the Rolling Stock and Telecommunication Contractors. Integrated testing of each train with Train Radio system shall be done as under:
- (i) Telecommunication Contractor shall develop Telecom-RS joint test procedure for mainline testing. It shall be responsibility of the Telecommunication Contractor and Rolling Stock Contractor to jointly test each 6-car train set on main line as per the Telecom-RS joint test procedure.
- 12.1.7.41 The Rolling Stock Contractor shall provide facilities including test track for comprehensive static, dynamic, and interface tests between the Rolling Stock and Telecommunication systems

at their premises. The Telecommunication Contractor shall be responsible for the provision of special test equipment and instrumentation.

- 12.1.7.42 Should the need arise for modifications in the configurations of respective equipment or systems as a result of the integration test or otherwise, the scope of work and division of responsibility shall be jointly agreed amongst the Contractors and detailed procedure shall be developed. The Rolling Stock Contractor shall provide the requisite man power to monitor and/or implement the modifications on the Rolling Stock for works involving the scope as identified in clause above.

EMC/EMI Interface

- 12.1.7.43 Regarding electromagnetic interference, the Telecommunication Contractor shall provide a list of frequencies and other sensitive requirements to the Rolling Stock Contractor, to enable the Rolling Stock Contractor to avoid such frequency bands in the design, and to provide devices to isolate the source of emission wherever required.
- 12.1.7.44 The Rolling Stock and Telecommunication Contractor shall ensure that the emission and immunity level of their respective equipment meet the requirements of EN50121-3-2.
- 12.1.7.45 The Contractors shall also jointly develop a test plan for verification of electromagnetic compatibility of traction and telecommunication systems. The Contractors shall work together to assure that all electronic and electrical equipment on the Rolling Stock functions properly without interference to the telecommunications sub-systems.
- 12.1.7.46 The cable layout of the Telecommunication systems in the cable ducts provided by the Rolling Stock Contractor shall be jointly agreed. The separation between Telecommunication cables and power cables of 750V DC, 415V three-phase AC, 230V AC single phase, 110V DC rating for traction and other power supplies or any other similar higher voltage rating shall be in accordance with the international practice and jointly agreed.
- 12.1.7.47 The cable ducts should be earthed notionally at every 2 m and also at the ends and should be in accordance with accepted international practices.

Scope of Interface

12.1.7.48 The Telecom and RS Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Item	RS Contractor	Telecom Contractor
1	6-car consists trains shall be equipped with following main equipment a. On-board TETRA equipment b. On-board BBRs equipment c. Antennae for TETRA d. Antennae for BBRs Inclusive of all types of cables, accessories etc.	To provide space in the vehicle design for fixing and installation and interfaces at the manufacturers facility, by the RS Contractor under the supervision of Telecommunication Contractor to achieve overall system functionalities	To supply/deliver all the equipment under column "item Description" to the Rolling Stock Contractor's works as applicable
2	Power supply and earthing for on-board Train Radio and BBRs equipment	To provide the required voltages and earthing	Furnish required voltage values and earthing requirements to Rolling Stock Contractor
3	Logging of on-board information from Train Radio	Provide the recording and monitoring of signals and Faults from Train Radio in TCMS	Telecommunication Contractor to co-ordinate with Rolling Stock Contractor for signal levels and protocols
4	On-board information from TCMS to Train radio	Shall provide rake ID and provision shall be made in TCMS to connect with train radio	Shall specify the connection requirement and co-ordinate
5	On-board announcement from OCC including the triggering of pre-recorded messages	Rolling Stock Contractor shall provide for necessary hardware interface, display for on-board and PA system inside the cars	Telecommunication Contractor shall provide necessary signals on-board to Rolling Stock Contractor
6	On-board equipment for CCTV image transmission to Cab/OCC	Rolling Stock Contractor shall provide for necessary on-board cameras, POE switches, display equipment and inter connections, space and appropriate interface/protocols for Telecom equipment	Telecommunication Contractor shall provide necessary On-board BBRs equipment to Rolling Stock Contractor for image transmission to OCC
7	Climatic requirements for on-board Train Radio Cab equipment	Rolling Stock Contractor to provide conditioning air from the saloon to all relevant telecom installations to maintain a nominal temperature of 25°C. Conditioned air ventilation shall be provided by the Contractor for the console	Telecommunication Contractor to specify at an early date, the total heat load wattage, and maximum permitted operating temperature
8	EMC/EMI interface between the Rolling Stock and Telecommunications	Rolling Stock Contractor shall ensure the compliance of the requirements of Telecommunication Contractor for on board Radio equipment	Telecommunication Contractor shall detail the EMI/EMC requirements for Radio equipment to Rolling Stock at an early date and also jointly ensure the compliance with Rolling Stock

SN	Item	RS Contractor	Telecom Contractor
9	Train lines / communication architecture and media	Rolling Stock Contractor shall provide the necessary train lines/communication media as per agreed interface	Telecommunication Contractor shall specify at an early date the requirement of Train Lines/communication architecture and media
10	Hot axle box detection system	Rolling Stock Contractor shall install on-board temperature sensors for detecting axle box temperature on all axles boxes of 126 cars and supply wayside equipment for gathering and processing the data from on-board sensors in 3 stations of each line (Line-1 and Line-2) i.e. 6 stations in total on both UP and DOWN track separately. Rolling Stock Contractor shall also provide one data base server with workstation in OCC, required software and communication network from way side equipment up to station Telecom Equipment Room (TER). Data processing, interface equipment on both ends i.e. at wayside station and OCC shall be the responsibility of Rolling Stock Contractor	Telecommunication Contractor shall provide Ethernet/Fiber Optic channel from station TER (Telecom Equipment Room) to CER (Central Equipment Room) of OCC

12.1.8 INTERFACES WITH TELECOM CONTRACTOR (NEW LINES)

Train Operating Modes

- 12.1.8.1 Telecommunication Contractor shall interface with Signaling and Rolling Stock Contractor for the details of train operating modes.
- 12.1.8.2 The train-borne Automatic Train Control (ATC) system will consist of Unattended Train Operation (UTO), Automatic Train Operation (ATO) and Automatic Train Protection (ATP) systems on New Lines (Reach-5).
- 12.1.8.3 The Rolling Stock required for New Lines shall be fitted with ATP/ ATO/UTO system.
- 12.1.8.4 There will be on-board Radio system. The supply/delivery of Train Radio System for new trains shall be responsibility of the Contractors for Telecommunication, and shall be required to liaise closely with the Rolling Stock Contractor, in regard to installation, testing and commissioning of the Telecommunication equipment

TETRA Radio System

The TETRA Radio System shall provide a digital, standard radio communications system, conforming to the TETRA standards as defined by ETSI, capable of facilitating system-wide voice and data communication. The TETRA Radio System (TRS) shall guarantee secure Operational Communications for the OCC, BCC, Train operators, station staff, depot staff and mobile maintenance personnel. Communication shall be configurable between any of these user groups.

Interface Requirements between Telecommunication and Rolling Stock Contractors

- 12.1.8.5 The Telecommunication Contractor shall provide the Rolling Stock Contractor with the final list of equipment to be provided on the Rolling Stock. The sizes and weights of the on-board Radio equipment and antennae etc., to be mounted on the Rolling Stock shall also be provided as applicable
- 12.1.8.6 The Telecommunication Contractor shall deliver to the Rolling Stock Contractor's factories, all train-borne radio equipment, as applicable, and data to enable fitting and testing. Connector fixing and cable harnessing shall be done by RS Contractor under the supervision of Telecommunication Contractor.
- 12.1.8.7 The Telecommunication Contractor shall supply all the train radio equipment including the Train Radio Control Panel at the Rolling Stock Contractor's factory. Telecommunication Contractor, with the details provided by Rolling Stock Contractor shall ensure that the exterior finish and colours of the respective equipment suitably harmonize with that of the cab and the vicinity.
- 12.1.8.8 Interfacing wiring for each module provided by the Telecommunication Contractor including the interfacing wiring between the Telecommunications Contractors equipment shall terminate in a quick disconnect robust plug connector suitable for traction applications, with direct cable connection as far as possible. All cable connectors shall be identified within the cubicle using robust cable markers with distinctive colours for identification, for e.g. safety function cables.
- 12.1.8.9 For all relay contact interfaces (if applicable), the Telecommunication Contractor shall provide auto-contact jam detection and contact bounce elimination function to ensure proper operation of the system. Relays for safety functions shall comply with the appropriate internationally accepted standard specification.
- 12.1.8.10 The Telecommunication Contractor shall provide the Rolling Stock Contractor with the number of wires/communication architecture and protocols required between cars of a married pair and between married pairs to transmit signals from one end of the rake to the other end through electrical jumpers.
- 12.1.8.11 Vehicle control circuits shall be developed by the Rolling Stock Contractor. During the design stage, all vehicle control circuits incorporating the identified interfaces shall be provided to the Telecommunication Contractor, as applicable. The Telecommunication Contractor shall provide specific observations on these circuits to the Rolling Stock Contractor. The Rolling Stock Contractor shall suitably incorporate any (if applicable) observations in the design.
- 12.1.8.12 Certain vital and non-vital signals from Telecommunication side shall be monitored by TCMS. Details regarding the signals to be monitored shall be jointly agreed between the Rolling Stock and Telecommunication Contractors and submitted for Engineer's review.
- 12.1.8.13 Hot axle box detection system for monitoring of axle box temperature shall be provided by Rolling Stock Contractor. On-board temperature sensors for detecting axle box temperature shall be provided and installed on all axle boxes of all cars by Rolling Stock Contractor. The wayside equipment for gathering and processing the data from on-board sensors shall be provided in the designated stations on both UP and DOWN track separately by Rolling Stock Contractor. One data base server with workstation in OCC, required software and communication network from wayside equipment up to station Telecom Equipment Room (TER) shall be provided by Rolling Stock Contractor. The Telecom Contractor shall provide Ethernet/Fibre Optic

channel from station TER (Telecom Equipment Room) to CER (Central Equipment Room) of OCC. Data processing, interface equipment on both ends i.e. at wayside station and OCC shall be the responsibility of Rolling Stock Contractor.

Telecommunication details to be used by RS Contractor

12.1.8.14 The following data shall be provided:

- (i) The maximum power consumed by the Telecommunications Contractor's equipment from the 110V DC supply under all specified operating conditions.
- (ii) The number of train wires required, and the function of each wire/communication architecture and protocols
- (iii) All control logic outputs.
- (iv) Electrical characteristics of the interconnection cabling and wiring.
- (v) Sensitivity levels, and frequencies, which must be avoided.
- (vi) The specific heat load for air conditioning purposes.
- (vii) The EMC/EMI requirements including the limiting value of photometric current, to obviate interference in the operation of telecommunication equipment; and
- (viii) Details of the provisions required to enable the transference of data from the train to the OCC.
- (ix) The physical dimensions of the equipment to be fitted on Rolling Stock

Train Radio (TETRA) Equipment Cubicles

12.1.8.15 The Rolling Stock Contractor shall supply the Train Radio equipment cubicle enclosure(s). All supports, braces, mounting holes, cabling apertures, accessories etc. required for mounting the cubicle and its equipment shall be properly coordinated between Telecommunication Contractor and the Rolling Stock Contractor to ensure secure mounting, and access. The cubicle(s) shall be resiliently mounted.

12.1.8.16 To achieve the Train radio functions, the Telecommunication Contractor shall identify any interfacing circuits specifically required for Train Radio operation and liaise with the Rolling Stock Contractor.

12.1.8.17 The Telecommunication Contractor shall respectively identify the voltage free contacts to be provided by the Rolling Stock Contractor, including the number and type of electrical signals required between the Train Radio equipment and the equipment provided by the Rolling Stock Contractor. The Contractors shall co-ordinate to agree on levels and protocols for each such signal.

12.1.8.18 As a minimum, all electronic equipment to be mounted on Rolling Stock, including those provided by the Telecommunication Contractor shall comply with IEC 60571: Electronic Equipment used on Rail Vehicles, for design, manufacture and testing, and shall use components purchased against an internationally recognized quality assurance and reliability certification procedure.

Antennae

12.1.8.19 The Telecommunication Contractor shall identify roof-mounted antennae (for train radio), and associated disconnection box mounting brackets and location requirements to identify cable and conduit routes required to antennae.

- 12.1.8.20 The Telecommunication Contractor for their respective scope shall supply the necessary disconnection boxes, terminal blocks, cables and adaptation mounting brackets, flexible conduit assemblies complete with connectors and cables from antennae to the junction boxes.
- 12.1.8.21 The Rolling Stock Contractor will provide the antenna mounting brackets, conduits, support or clamping arrangements, fixture and accessories to ensure security and reliability.
- 12.1.8.22 The antenna system shall not contravene the kinematic envelope and fully meet the radio coverage requirements both for normal and reverse directions of train working.
- 12.1.8.23 The Telecommunication Contractor shall furnish the RS Contractor with full mounting details, apertures, fixing holes, etc.

Interface between TCMS and Telecommunication equipment

- 12.1.8.24 The Rolling Stock Contractor shall provide an on-board Train Control Management System (TCMS), to log information from the Train radio equipment supplied by the Telecommunication Contractor, in addition to the information shown in the Rolling Stock specification.
- 12.1.8.25 The signals to be supplied from the TCMS to the equipment of Telecommunications Contractor shall be decided jointly between the two Contractors.

Power supply and earthing arrangements

- 12.1.8.26 The Rolling Stock Contractor shall provide independent 110 V DC power supply circuits/Power Supply requirement to Train Radio equipment as per interface document including positive and negative poles. Both Contractors shall co-ordinate to agree the power supply voltages and arrangements.
- 12.1.8.27 The Rolling Stock Contractor shall provide dedicated earthing arrangements for the train borne Radio equipment. The Telecommunication Contractor shall specify the earth impedance required.
- 12.1.8.28 The power supply cable between the train power supply and the Radio train borne power equipment shall be segregated, as short as possible and directly connected to the supply without any intermediate connection.

Other interface requirements

- 12.1.8.29 The Telecommunications Contractors shall furnish the Rolling Stock Contractor with the interface required between the train radio system and the on-train public address system to allow on-board announcements to be made from the OCC. The interface shall provide the necessary means to enable OCC to initiate triggering of real time announcement or pre-recorded messages in the on-train public address system.
- 12.1.8.30 The complete on-train public address system, and interface hardware, including the transmission link, and a communication panel shall be furnished by the Rolling Stock Contractor. Levels and protocols shall be agreed between the two Contractors.

- 12.1.8.31 Signalling Contractor shall provide Train ID to Train radio through ATS-Train Radio interface. However, Rolling Stock Contractor shall also provide Train ID to Train Radio through TCMS train radio interface.
- 12.1.8.32 The Telecommunications Contractors shall furnish the Rolling Stock Contractor with the interface required between the train radio system and the TCMS for recording the initiation, termination, and success or failure of emergency calls initiated by the train operator and/or OCC on the radio. The hardware interface in the train shall be furnished and installed by the Rolling Stock Contractor. Levels and protocols shall be agreed between the two Contractors.
- 12.1.8.33 There shall be a provision of roving attendant to make the passenger announcement through his mobile handset (Tetra) inside a particular train through train radio network using radio identification number. The interface between train radio and on board communication (PA/PIS) system shall be done by Rolling Stock and Telecommunication Contractors.
- 12.1.8.34 Telecommunication Contractor and Rolling Stock Contractor shall interface for initiation, termination and success or failure of emergency calls initiated by passengers to OCC. The initiation of this passenger call shall automatically focus a CCTV camera on the passenger and raise a prompt on a suitable terminal of OCC/BCC. The hardware interface in the train shall be furnished and installed by RS Contractor.

Factory Installation and Testing

- 12.1.8.35 All the special equipment associated with the train borne Radio system, including the interface cables/wires between the Train Radio equipment shall be designed and supplied by the Telecommunication Contractor to the Rolling Stock Contractor's premises. Each Contractor shall be aware of the locations of manufacturing plants, which could concurrently be manufacturing cars.
- 12.1.8.36 The Telecommunications Contractor shall be responsible for providing all data and training of Rolling Stock Contractor's staff in all aspects of Telecommunication equipment installation and testing where applicable. The first set of Train Radio equipment shall be installed by Rolling Stock Contractor, under the supervision of the Telecommunication Contractor's representatives.
- 12.1.8.37 The Rolling Stock Contractor will be responsible for installing of wiring and equipment, and its testing on each car to the functioning standard agreed with the Telecommunication Contractor.
- 12.1.8.38 Testing of each car shall comply with the accepted international standards agreed between the two Contractors as agreed with the Engineer. Initial Integration tests (static and dynamic) shall be done at the Rolling Stock factory and carried out by the test personnel of both Contractors jointly. Further main line integration tests will be required to be carried out to ensure all train control functions between OCC and Train which will be required to be done jointly by the Rolling Stock and Telecommunication Contractors on site in Bangalore. The test certificate subsequently shall be issued jointly by the Rolling Stock and Telecommunication Contractors. Integrated testing of each train with Train Radio system shall be done as under:
- (a) Telecommunication Contractor shall develop Telecom-Rolling Stock joint test procedure for mainline testing. It shall be responsibility of the Telecommunication Contractor and Rolling Stock contractor to jointly test each 6-car train set on main line as per the Telecom- Rolling Stock joint test procedure.

- 12.1.8.39 The Rolling Stock Contractor shall provide facilities including test track for comprehensive static, dynamic, and interface tests between the Rolling Stock and Telecommunication systems at their premises. The Telecommunication Contractor shall be responsible for the provision of special test equipment and instrumentation.
- 12.1.8.40 Should the need arise for modifications in the configurations of respective equipment or systems as a result of the integration test or otherwise, the scope of work and division of responsibility shall be jointly agreed amongst the Contractors and detailed procedure shall be developed. The Rolling Stock Contractor shall provide the requisite man power to monitor and/or implement the modifications on the Rolling Stock.

EMC/EMI Interface

- 12.1.8.41 Regarding electromagnetic interference, the Telecommunication Contractor shall provide a list of frequencies and other sensitive requirements to the Rolling Stock Contractor, to enable the Rolling Stock Contractor to avoid such frequency bands in the design, and to provide devices to isolate the source of emission wherever required.
- 12.1.8.42 The Rolling Stock and Telecommunication Contractor shall ensure that the emission and immunity level of their respective equipment meet the requirements of EN50121-3-1 and EN50121-3-2.
- 12.1.8.43 The Contractors shall also jointly develop a test plan for verification of electromagnetic compatibility of traction and telecommunication systems. The Contractors shall work together to assure that all electronic and electrical equipment on the Rolling Stock functions properly without interference to the telecommunications sub-systems.
- 12.1.8.44 The cable layout of the Telecommunication systems in the cable ducts provided by the Rolling Stock Contractor shall be jointly agreed. The separation between Telecommunication cables and power cables of 750V DC, 415V three-phase AC, 230V AC single phase, 110V DC rating for traction and other power supplies or any other similar higher voltage rating shall be in accordance with the international practice and jointly agreed.
- 12.1.8.45 The cable ducts should be earthed notionally at every 2 m and also at the ends and should be in accordance with accepted international practices.

Scope of Interface

- 12.1.8.46 The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include, as a minimum but not be limited to:

SN	Item	Telecom Contractor	RS Contractor
1	New 6-car consists trains shall be equipped with following main equipment <ul style="list-style-type: none"> On-board TETRA equipment Antennae for TETRA Inclusive of all types of cables, accessories etc.	To supply/deliver all the equipment under column "item Description" to the Rolling Stock Contractor's works as applicable	To provide space in the vehicle design for fixing and installation at the manufacturers facility, by the Rolling Stock Contractors under the supervision of Telecommunication Contractor to achieve overall system functionalities

SN	Item	Telecom Contractor	RS Contractor
2	Power supply and earthing for on-board Train Radio equipment	Furnish required voltage values and earthing requirements to Rolling Stock Contractor	To provide the required voltages and earthing
3	Logging of on-board information from Train Radio	Telecommunication Contractor to co-ordinate with Rolling Stock Contractor for signal levels and protocols	Provide the recording and monitoring of signals and Faults from Train Radio in TCMS
4	On-board information from TCMS to Train radio	Shall specify the connection requirement and co-ordinate	Shall provide rake ID and provision shall be made in TCMS to connect with train radio
5	On-board announcement from OCC including the triggering of pre-recorded messages	Telecommunication Contractor shall provide necessary signals on-board to Rolling Stock Contractor	Rolling Stock Contractor shall provide for necessary hardware interface, display for on-board and PA system inside the cars
6	Climatic requirements for on-board Train Radio Cab equipment	Telecommunication Contractor to specify at an early date, the total heat load wattage, and maximum permitted operating temperature	Rolling Stock Contractor to provide conditioning air from the saloon to all relevant Telecommunication installations to maintain a nominal temperature of 25°C. Conditioned air ventilation shall be provided by the Contractor for the console
7	EMC/EMI interface between the Rolling Stock and Telecommunications	Telecommunication Contractor shall detail the EMI/EMC requirements for Radio equipment to Rolling Stock at an early date and also jointly ensure the compliance with Rolling Stock	Rolling Stock Contractor shall ensure the compliance of the requirements of Telecommunication Contractor for on board Radio equipment
8	Train lines / communication architecture and media	Telecommunication Contractor shall specify at an early date the requirement of Train Lines/communication architecture and media	Rolling Stock Contractor shall provide the necessary train lines/ Ethernet connection/ communication media as per agreed interface
9	Hot axle box detection system	Telecommunication Contractor shall provide Ethernet/Fibre Optic channel from station TER (Telecom Equipment Room) to CER (Central Equipment Room) of OCC	Rolling Stock Contractor shall install on-board temperature sensors for detecting axle box temperature on all axles boxes of all cars and supply wayside equipment for gathering and processing the data from on-board sensors in the designated stations on both UP and DOWN track separately. Rolling Stock Contractor shall also provide one data base server with workstation in each associated OCC, required software and communication network from way side equipment up to station Telecom Equipment Room (TER). Data processing, interface

SN	Item	Telecom Contractor	RS Contractor
			equipment on both ends i.e. at wayside station

12.1.9 INTERFACES WITH POWER SUPPLY & TRACTION (PST) CONTRACTOR

Rolling Stock Contractor shall interface with power supply Contractor for interface with 3rd rail/750V DC supply.

The details of these Contracts and Contractors shall be made available during the execution of the Contract.

A detailed design consultant may be engaged by BMRCL for the design.

Power Supply and 3rd rail Contractor shall collect necessary data of track/points and crossing from track Contractor and Rolling Stock data from Rolling Stock Contractor for designing the 3rd rail including ramps in the points and crossing area. Power supply and 3rd rail Contractor shall undertake the gap study to determine the bridgeable gap (BG) and non-bridgeable gap for main line movement and for diverted track movement and will avoid discontinuity of power to the train on main line while negotiating point and crossing. During movement of train on diverted track continuity of the power from 3rd rail to the train be maintain to maximum extent possible. Necessary relevant parameters of Rolling Stock shall be coordinated /interfaced by the Rolling Stock Contractor with 3rd rail Contractor and track Contractor to produce harmonious and compatible design for the three systems viz. Rolling Stock, 3rd rail and Track point and Crossing.

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item no.	Item	Rolling Stock (RS) Contractor	PST Contractor
	Design Stage		
1	Supply of Basic data and information regarding <ul style="list-style-type: none"> • Speed/current characteristics • Speed/Traction Effort curves • Auxiliary power requirement • Motor kW and specifications • Acceleration and braking • Regeneration • Harmonics • Power factor correction • Current Collection equipment details 	Shall supply information to PST Contractor.	Shall incorporate details in the designs, system studies and verification of designs

Item no.	Item	Rolling Stock (RS) Contractor	PST Contractor
2	Arrangement of the Sectioning scheme	RS Contractor to note the details and confirm their suitability	Shall provide information and drawings/scheme to RS Contractor
3	Detailed drawings of current collection system.	Shall provide information to PST Contractor.	Shall take into consideration for the design of the traction System
4	Traction current	Shall provide information to PST Contractor.	Shall take into consideration for the design of the traction System and bonding plan.
5	Third rail details	Shall design the current collectors on the basis of third rail design particulars	Shall provide information regarding third rail dimensions, adjustment / dimensional tolerances and sectioning for design of current collectors of rolling stock
6	Harmonic limitations of the power supply	Shall incorporate into the design of collector shoes	Shall provide information to RS Contractor
7	Electrical and mechanical clearances between third rail support assemblies and collector shoe	Shall incorporate into the design of the collector shoe gear	Shall provide information to rolling stock Contractor
8	Drawings, material, springing, damping, sway and other relevant details of collector shoe gear	Shall provide information to PST Contractor	Shall take into consideration for third rail designs
9	Third rail non bridgeable gaps	Shall provide details of current collectors location and continues length of 750V DC bus, maintenance tolerances etc.	i) Shall consider the RS details of current collectors relative positions in a car, maintenance tolerances etc. for design of third rail ramps ii) Shall undertake gap study to determine the bridgeable gap (BG) and non-bridgeable gap for main line movement and for diverted track movement in order to avoid discontinuity of power to the train on main line while negotiating point and crossing for design of third rail and air gaps. iii) To avoid discontinuity in 750V DC for very short duration (small peak).
10	Maximum traction return current	Shall provide information to PST Contractor	Shall incorporate into the design of the 750 DC Third Rail Traction System.
C&I Stage			
11	All relevant items	Shall manufacture the RS as per agreed interfaces	Shall install the PST system as per agreed interfaces

Item no.	Item	Rolling Stock (RS) Contractor	PST Contractor
12	Location of Warning Boards and visual indications	Shall confirm the suitability	Shall supply and install the Boards and indications
	T&C Stage		
13	Testing and commissioning	Shall request 750V power supply in the Third Rail for testing and commissioning of Metro Cars; shall co-operate and ensure that the harmonics generated are within the agreed levels	Shall provide 750 V dc power supply and co-ordinate with RS Contractor to conduct testing and commissioning of Metro Cars. Shall jointly check the electrical loads, harmonic levels and return current coming on Traction sub-station from Rolling stock
14	Integrated testing & commissioning	Shall lead the ITC including current collection test. Shall install on-board equipment and underframe camera for current collection test.	Shall participate for the ITC. Shall analyze the flash points on the third rail observed during current collection test and take necessary corrective action.
15	Negotiation of non-bridgeable gap in coasting	Shall provide train and co-ordinate with PST Contractor for checking negotiability of non-bridgeable gap in coasting and identify the maximum safe speed before entering coasting	Shall demonstrate the safe speed to negotiate the Non-Bridgeable Gap in coasting.
	Maintenance Stage		
16	Nil		

12.1.10 INTERFACES WITH PSD CONTRACTOR

Scope of Interface & Division of Responsibilities

- 12.1.10.1 The Rolling Stock Contractor shall provide necessary signals to the Signaling and Train Control Contractor for proper functioning of Platform Screen Door (PSD). The Rolling Stock and Signaling and Train Control Contractor shall interface for exchange of signals and develop protocol for proper working of Platform Screen Door (PSD).
- 12.1.10.2 The Signaling Contractor and the Rolling Stock Contractor shall work with the Platform Screen Door (PSD) Contractor on coordinating the train door and platform screen door (PSD) control and defective train/PSD door interface including advance passenger notification of defective train door/PSD.
- 12.1.10.3 The two door leaves at each passenger doorway shall be synchronously controlled and shall provide a door clear opening width of equal spacing of not less than 1.4 meter. The location and size of the door panels are important for the PSD equipment supplier.
- 12.1.10.4 The passenger door pitch shall be approximately equally spaced over the length of the rake.

12.1.10.5 The Rolling Stock Contractor shall coordinate with the designated Contractor for PSD, signaling & train control and Telecommunication to provide the necessary interface information data including, ATP/ATO/UTO signals to synchronize the opening and closing of PSDs with opening and closing of train door, station dwell times, door opening and closing announcements, signals for "Train Arriving" and Train Leaving" announcement, and all else necessary for the proper design, interface, interface and operation of the PSDs. Different failure scenarios of PSD as well train doors including information to passengers shall be considered.

12.1.10.6 Integrated testing and commissioning shall be jointly performed by RS Contractor, S&TC Contractor, Telecom Contractor and PSD/PSG Contractor

12.1.10.7 The PSD Contractor shall be responsible for all on-site testing of their equipment. The Rolling Stock Contractor shall provide a qualified engineer at the Site to assist in the interface testing of the Rolling Stock and PSD.

12.1.10.8 The Rolling Stock Contractor is responsible for interfacing with the PSG Contractor with determining the integral functionality for PSG's. The roles and activities of the two Contractors shall include minimum following but not limited to:

The functional interface between this Rolling Stock Contractor and the PSD Contractor shall be in accordance with the Interface Schedule in Table below:

Item No.	Purpose / Subject of interface	Rolling Stock (RS) Contractor	PSG/PSD Contractor
	Design Stage		
1	Synchronization of PSD and train doors to minimize the time lag not more than 1s	Provide the train door time delay (from 0 to 5s). Adjust the train door operation to facilitate door synchronization between train door and PSD.	Minimize the time lag of operating PSD on receipt of door open/close command from Signalling System.
2	Synchronization of door operation	Synchronized door operation through Signalling. In case of a particular door failure, both train door and PSD at that particular location will not open.	Synchronized door operation through Signalling. In case of a particular door failure, both train door and PSD at that particular location will not open.
3	Door alignment	Provide the drawings showing the door pitch, between cars dimension, cabin door location.	To align the door center line with that of train door.
4	Advance warning of defective train door/PSD	<ol style="list-style-type: none"> 1. Indicate location of defective train door to the Signalling. 2. In case of defective PSD on upcoming station, display message at relevant train door prior to train arrival to notify passengers that the particular train door will not open. Signalling System will provide the location of the defective PSD to the train. 	<ol style="list-style-type: none"> 1. Indicate location of defective PSD to the Signalling System. 2. In case of defective train door on upcoming train, display message at relevant PSD prior to train arrival to notify passengers that the particular PSD will not open. Signalling System will provide the location of the defective train door to the PSD system.

Item No.	Purpose / Subject of interface	Rolling Stock (RS) Contractor	PSG/PSD Contractor
5	Ensure a Maximum platform gap width of 40mm.	Coordinate with PSD Contractor and provide the train kinematic envelope (KE) requirements to achieve the desired platform gap width.	Coordinate with Significant Contractor and provide
6	EED (of PSD) to align position of EAD (Emergency Access Device) of RS door	Shall align (also considering unaligned position of any EAD with respect to EED due to the stopping of the train at abnormal location on the platform) Emergency Access doors (EED) or PSD to avoid any kind of hindrance while accessing EAD so that at least one EAD shall be operated on platform.	Shall provide location and operation details of EAD (Emergency Access Device) to PSD Contractor.
7	Access of Parking brake release handle in under frame	Shall provide location parking brake release handle with respect to kinematic envelope / structure gauge.	Shall consider the feasible/safe passage to access parking brake release handle to be operated at platform.
8	No obstruction to driver	Shall provide cab door distance from the nearest saloon door to PSD Contractor	Shall provide last and first PED (Platform End Door) dimension to RS Contractor. Shall avoid obstruction to driver access through cab door when PED open. Shall look for the possibility to access to PSD operating panel (PSL) through driving cab side window in case of manual operation/handling of PSD by driver (specifically, short female train operator).
C&I Stage			
9	All relevant items	Shall manufacture the RS as per agreed interfaces	Shall install the PSD system as per agreed interfaces
T&C Stage			
10	Integrated testing & commissioning	Shall participate in the ITC (led by S&TC Contractor)	Shall participate for the ITC (led by S&TC Contractor)
Maintenance Stage			
11	Nil		

12.1.11 INTERFACES WITH TRACK WORK (TRW) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item no.	Item	Rolling stock (RS) Contractor	Track Work (TRW) Contractor
	Design Stage		
1	Track alignment drawings	Rolling Stock Contractor shall use the information for his design and train running simulation	Track Contractor shall provide the RS Contractor with the detailed track alignment drawings
2	Kinematic Envelope / structure gauge	Shall provide kinematic envelope / structure gauge information to Track Contractor	Take into account for checking the infringement at construction stages
3	Track design / drawings	<p>The Rolling Stock Contractor shall provide the wheel profile details and other train parameters to the Track Contractor. The wheel and rail static and dynamic interface shall be optimized to achieve a good operational, maintenance and riding comfort performance.</p> <p>RS Contractor shall incorporate in its design the track parameters</p>	<p>Shall provide information regarding track parameters including the track form and track work component stiffness, track gauge, rail type& hardness, curve radius, cant and all the parameters together with the tolerance and limits of each parameter</p> <p>Track Contractor shall consider RS parameters in track design</p>
4	Gauge widening	RS Contractor shall provide necessary information	The Track Contractor shall liaise with RS Contractor for the requirement and extent of Gauge widening on very sharp curves.
5	Flange way clearances	RS Contractor shall provide necessary information	The Track Contractor shall liaise with RS Contractor for determining the requirement (including the required flange way clearances) for the provision of check / restraining rails, if considered, on very sharp curves.
6	Simulation Studies	Shall carry out simulation studies & provide results with respect to attainable speed along the alignment.	The values of cant to be provided on every curve shall be fine-tuned based on the attainable speeds. The Track Contractor shall provide the cant accordingly during construction stage.
7	Buffer stops design	<ul style="list-style-type: none"> Shall provide details of Rolling Stock Shall liaise with Track Contractor to verify the design of friction buffer stops is interfaced satisfactorily with the car design 	The Track Contractor shall liaise with the Rolling Stock Contractor to design the buffer stop and shall consider such details for supply and installation of buffer stops
8	Calculations for Design of walkway slab	Shall study the track geometry including horizontal and vertical profile for the entire project. The project is designed with side evacuation. The Rolling Stock Contractor and Track Contractor shall jointly submit the calculation of horizontal and vertical shift of carbody on inside curve and outside curve in stationary condition and running condition.	<ul style="list-style-type: none"> The project is designed with side evacuation. The Rolling Stock Contractor and Track Contractor shall jointly submit the calculation of horizontal and vertical shift of carbody on inside curve and outside curve in stationary condition and running condition. Walkway slab shall be designed by civil Contractor based on the calculation submitted jointly by Rolling Stock Contractor and Track Contractor to ensure

Item no.	Item	Rolling stock (RS) Contractor	Track Work (TRW) Contractor
		Walkway slab shall be designed by civil Contractor based on the calculation submitted jointly by Rolling Stock Contractor and Track Contractor to ensure that gap between walkway and car floor shall not exceed 600mm as it is not possible to accommodate bridgeable ramp (emergency ramp) with more than 600 mm length under the train seat.	that gap between walkway and car floor shall not exceed 600mm as it is not possible to accommodate bridgeable ramp (emergency ramp) with more than 600 mm length under the train seat.
9	Track hardness	RS shall incorporate in his design	Shall provide information to RS Contractor
10	Checking of track construction envelope	To provide skeleton vehicle of structure gauge and take lead for running structure gauge skeleton vehicle to identify infringement of structure along the track including 3 rd rail installation and Signalling Equipment and notify the infringement to designated Contractor.	Shall co-ordinate
C&I Stage			
11	All relevant items	Shall manufacture the RS as per agreed interfaces	Shall install the track system as per agreed interfaces
12	Bridge plate	RS shall design and supply	Shall perform and submit joint calculations along with RS Contractor as per Item at SN 8 above
13	Construction and installation	Required to conduct test run with one car at low speed in the viaduct / tunnel sections	Shall participate in test run and perform modifications, if required
T&C Stage			
14	Integrated testing & commissioning	Shall provide results of test runs including those pertaining to track conditions.	Shall associate during integrated testing & commissioning and carryout necessary rectification of track.
15	Structure gauge checking	Shall provide structure gauge and manpower	Shall jointly measure the various clearances required for structure gauge and shall rectify the defects noticed in track area.
16	KE test	Shall provide the train with KE profile	Shall jointly check whether KE infringement is there or not Shall rectify the defects noticed as relevant to track work
Maintenance Stage			
17	Nil		

12.1.12 INTERFACES WITH M&P CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item no.	Purpose / Subject of interface	Rolling stock (RS) Contractor	M&P Contractor (M&P)
	Design Stage		
1	Automatic Train Wash Plant	Define special water quality requirements if any. <ul style="list-style-type: none"> • Share the Drawings of the train. • To provide details of infringing objects if any, which cause hindrance to the washing • Share Rolling Stock dimensions, profile SOD and other details to design wash plant. • Provide the details of the detergents to be used. 	Provide plant GAD and other details as required by RS Contractor
2	CNC Under floor Wheel Lathe with Synchronized Shunting System	<ul style="list-style-type: none"> • Share Train data / drawing as required by M&P Contractor (including SOD) • Share Wheel cross section drawing • Share Type of brake for machining • Share Coupler details for shunting • Share wheel, bogie, brake disc data related to tare load, axle load, inter-wheel distance in bogie, allowances for wheel diameter difference on the same axles, on the same bogie, on different bogie of same coach required for design of machine. • Share data for haulage requirement and auto coupler details 	Provide plant GAD and other details as required by RS Contractor
3	Under floor train lifting system for 6-car unit	Share Train data / drawings as required by M&P Contractor Share Lifting points details with lifting pad dimensions To ensure that there is no infringement in the vertical plane below the lifting points.	Provide plant GAD and other details as required by RS Contractor
4	Mobile lifting jacks for 6-car unit	<ul style="list-style-type: none"> • Share Train data / drawings as required by M&P Contractor • Share Lifting points details with lifting pad dimensions • To ensure that there is no infringement in the vertical plane below the lifting points. 	Provide plant GAD and other details as required by RS Contractor
5	Bogie Testing Machine	<ul style="list-style-type: none"> • Share Bogie data / drawings as required by M&P Contractor • Share Wheel data / drawings 	Provide plant GAD and other details as required by RS Contractor

Item no.	Purpose / Subject of interface	Rolling stock (RS) Contractor	M&P Contractor (M&P)
6	Rescue Vehicle with Re-railing & Allied Equipment	<ul style="list-style-type: none"> Share Train data / drawings and coupler details as required by M&P Contractor 	<ul style="list-style-type: none"> Provide plant GAD and other details as required by RS Contractor CRS requirements to be complied
7	Instrumented Third Rail Maintenance Vehicle	<ul style="list-style-type: none"> Share Train data / drawings as required by M&P Contractor Share Coupler details Share collector shoe drawing / details 	<ul style="list-style-type: none"> Provide plant GAD and other details as required by RS Contractor CRS requirements to be complied
8	Battery operated Rail-cum-Road Shunter	<ul style="list-style-type: none"> Share Train data / drawings and coupler details as required by M&P Contractor 	Provide plant GAD and other details as required by RS Contractor
9	Multi-functional work station	<ul style="list-style-type: none"> Share Train data / drawings as required by M&P Contractor Share traction drawing / details 	Provide plant GAD and other details as required by RS Contractor
C&I Stage			
10	All relevant items	Shall manufacture the RS as per agreed interfaces	Shall manufacture and install the respective M&Ps as per agreed interfaces Design Manufacture and supply the M&P to suit the Rolling Stock.
T&C Stage			
11	Testing & commissioning	Shall collaborate and associate for testing & commissioning of respective M&Ps as required	Shall lead the testing & commissioning of respective M&Ps and collaborate / associate with RS Contractor as required
Maintenance Stage			
12	Nil		

12.1.13 INTERFACE WITH TVS CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Rolling Stock Contractor	TVS Contractor
Design Stage			
1	Train configuration information	Shall provide the details of train configuration and technical specification for Subway Environmental Simulation to design Tunnel ventilation and Track way exhaust system	Shall coordinate and obtain the details of train configuration and technical specification for Subway Environmental Simulation to design Tunnel ventilation and Track way exhaust system

Item No.	Subject	Rolling Stock Contractor	TVS Contractor
2	Train operation data	Shall provide the details of train speed, acceleration, deceleration, dwell time and operating headways in each underground stations and tunnels to design Tunnel ventilation and Track way exhaust system	Shall coordinate and obtain the details of train speed, acceleration, deceleration, dwell time and operating headways in each underground stations and tunnels to design Tunnel ventilation and Track way exhaust system
3	Train air-conditioner heat release data	Shall provide data of heat release rate from the train air-conditioners	Shall incorporate in the design
4	Train brake system heat release data	Shall provide data of heat release rate from the train brake system	Shall incorporate in the design
5	Location of air conditioners of cars	Shall indicate location of the car air conditioners viz.-a-viz. the train	Shall incorporate in his design as regard to location of track way exhaust duct
6	Train fire and heat release load	Shall indicate the fire load of the train	Shall incorporate in his design
7	Heat release rate from traction and auxiliary equipment and their location	Shall furnish data	To use data in TVS design
C&I Stage			
8	All relevant issues	Shall coordinate appropriately to ensure the agreed requirements are implemented	Shall construct and install the TVS system as per the agreed designs
T&C Stage			
9	System testing and commissioning	Shall participate for system testing	Shall participate for system testing
O&M Stage			
10	TVS system O&M	Shall support the O&M activities of TVS system.	Shall Co-Ordinate.

12.1.14 INTERFACE WITH ECS CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Rolling Stock Contractor	ECS Contractor
Design Stage			
1	Location of air-conditioners of Cars	Rolling Stock Contractor shall indicate location of the car air-conditioners vis-à-vis the train	ECS Contractor shall incorporate in his design as regard to location of Track way exhaust duct

Item No.	Subject	Rolling Stock Contractor	ECS Contractor
	(Applicable without PSD/PSG)		
2	Heat release rate from air- conditioners (Applicable without PSD/PSG)	Rolling Stock Contractor shall provide data of heat release rate from the air-conditioners	For design review of ECS equipment selection
3	Design stage (Applicable without PSD/PSG)	Shall provide the details of train speed, acceleration, deceleration, dwell time and operating headways in each underground station to do PSD Infiltration and ex filtration simulation and to calculate heat load capacities in platforms	Shall get the details of train speed, acceleration, deceleration, dwell time and operating headways in each underground station to do PSD Infiltration and ex filtration simulation and to calculate heat load capacities in platforms
	C&I Stage		
4	All relevant issues	Shall coordinate appropriately to ensure the agreed requirements are implemented	Shall construct and install the ECS system as per the agreed designs
	T&C Stage		
5	System testing and commissioning	Shall participate for system testing	Shall participate for system testing
	O&M Stage		
6	Nil		

12.1.15 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

General

12.1.15.1 BMRCL has plans to implement state-of-the-art IT-based Enterprise Asset Management System (AMS), which shall enable BMRCL to manage and optimize various processes (viz. maintenance management, engineering management, O&M relationship management, supply chain management, reporting etc.)

12.1.15.2 The RS Contractor shall be required to coordinate and interface with AMS Contractor for successful integration of Rolling Stock Assets and TCMS into the Asset Management System.

12.1.15.3 The rolling stock components / equipment to the required levels of breakdown shall be entered into the AMS.

12.1.15.4 The rolling stock data shall be fed into the AMS broadly in three forms:

- (a) Predetermined set of active failures and other relevant data shall be transmitted to OCC/Depot via wireless network. AMS shall be able take in this data for processing.

- (b) Data shall be downloaded from TCMS through GPRS or WLAN at predetermined intervals or locations. AMS shall be capable of interfacing with the concerned database and take in filtered data as per design.
- (c) Other data will be fed manually in the AMS.

12.1.15.5 Preventive and corrective maintenance data generated by the TCMS to raise the work request /work orders, and to update the equipment parameter reading

12.1.15.6 The point of interface to the AMS will be the AMS depot (or other location) rack via Ethernet LAN connectivity.

Responsibilities of Interfacing Parties

Below table provides the Responsibility Matrix for seamless integration between AMS to TCMS:

SN	Description	Responsibility
1	Analyzing Train Diagnostic Data for Critical Faults and converting them to Work Requests in AMS for immediate attention to Maintenance staff to take appropriate action.	AMS Contractor
2	Automatic download of the TCMS fault Data to Real Time Database or RTD (Centralized Database). From Here data would be picked by AMS for Analysis. This is the connectivity point between AMS and TCMS.	RS Contractor (TCMS Vendor)
3	Filtering of only Required (Criticality 1 and 2) to be pushed to AMS via agreed protocol for data exchange.	RS Contractor (TCMS Vendor)
4	Categorizing the Total fault list for TCMS on criticality basis.	RS Contractor (TCMS Vendor)
5	Finalizing the Meter/ counters (Operation counts of equipment) to be captured in AMS. This data would be used by AMS to trigger preventive maintenance and condition-based maintenance in AMS	RS Contractor (TCMS Vendor)
6	Provide the agreed Meter/ counter details to AMS for processing along with fault data	RS Contractor (TCMS Vendor)
7	Finalizing the fault / meter parameters to be exchanged between AMS and TCMS systems	Both Contractors
8	Creating a final fault List that will be part of AMS diagnosis from the overall fault List	RS Contractor (TCMS Vendor)
9	Filtered fault / Meter list approval	BMRCL / Engineer
10	Creating a fault/ Meter database in AMS	AMS Contractor
11	Creating an Interface Design for Data exchange	Both Contractors
12	Interface design document signoff	Both Contractors / BMRCL
13	Developing interface to push data to AMS	Both Contractors
14	Receiving and processing data to create work requests in AMS	AMS Contractor
15	Preparing test data for test cases	Both Contractors
16	Preparing test Cases for interface Test	Both Contractors
17	Testing Interface for required functionality	Both Contractors
18	Test Report Sign Off	Both Contractors / BMRCL
19	Deploying the interface on Test/ Production Environments	AMS Contractor
20	Technical Design Document submission and Sign Off	Both Contractors / BMRCL

CHAPTER 13

13.0 TELECOM SYSTEM INTERFACES

13.1.1 INTERFACES WITH ELEVATED CIVIL CONTRACTORS

Refer to [Para 2.1.7 above](#)

13.1.2 INTERFACES WITH UG CIVIL CONTRACTORS

Refer to [Para 3.1.7 above](#)

13.1.3 INTERFACES WITH DEPOT CIVIL CONTRACTORS

Refer to [Para 4.1.7 above](#)

13.1.4 INTERFACES WITH ELEVATED E&M CONTRACTORS

Refer to [Para 5.1.4 above](#)

13.1.5 INTERFACES WITH UG E&M CONTRACTORS

Refer to [Para 6.1.4 above](#)

13.1.6 INTERFACES WITH DEPOT E&M CONTRACTORS

Refer to [Para 7.1.5 above](#)

13.1.7 INTERFACES WITH ELEVATED FINISHING WORKS CONTRACTORS

Refer to [Para 8.1.4 above](#)

13.1.8 INTERFACES WITH UG FINISHING WORKS CONTRACTORS

Refer to [Para 9.1.4 above](#)

13.1.9 INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS

Refer to [Para 10.1.5 above](#)

13.1.10 INTERFACES WITH S&TC CONTRACTOR

Refer to [Para 11.12 above](#)

13.1.11 INTERFACES WITH RS CONTRACTOR

Refer to [Para 12.1.7 above](#) for Extension Lines and [Para 12.1.8 above](#) for New Lines

13.1.12 INTERFACES WITH PST CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Item Description	Telecom Contractors	PST Contractor
	Design Stage		
1	Various issues	<ul style="list-style-type: none"> Shall coordinate / cooperate / exchange requisite information for various interface issues Shall furnish the location of telecom cables and telecom distribution equipment / telephone exchanges in sufficient details for enabling 'modeling' of cables and for performing simulation study on the Electromagnetic compatibility 	Shall coordinate / exchange information regarding the following interface issues: <ul style="list-style-type: none"> Obtain telecom cable information for performing EMC study and ensuring electromagnetic compatibility Telecom backbone network (channel allocation) for SCADA connectivity from stations / wayside to OCC/BCC (1+1 redundancy) Telephone connections at substations and other requisite locations ETS locations and emergency telephone thereof Earthing and bonding
	C&I Stage		
2	Control & Monitoring (C&M) data exchange	<ul style="list-style-type: none"> Will provide fiber optic port or Ethernet Port on FOTS network in TER Room, for the channels required for C&M data exchange and for interlinking the OCC's. Telecom Contractor shall plan interconnection in the CER/TER between copper cable network (FOTS) and provide the required bandwidth on FOTS system. 	Will supply and install suitable copper / optical fiber cables including convertor for connection from RTU to fiber optic port of Telecom equipment at: <ul style="list-style-type: none"> Each station telecom equipment room (from ASS, TSS, RSS) The station TER nearest to RSS, for connection from RSS including details of the cable termination

Item No.	Item Description	Telecom Contractors	PST Contractor
		<ul style="list-style-type: none"> Shall provide the space to install optic fiber converters at each station Telecom Equipment Room, the depot control room 	at the interface points of the Traction SCADA location.
3	Telephone connections to the internal telecom network	Provide a connected telephone at each ASS room, TSS, RSS Control Rooms, ECC desks, PSI depot, Supply Authority Substations.	Furnish the requirements and coordinate closely with telecom Contractor for provisioning of the telephone
4	Laying of C&M cables	Provide space (approx. 10cm ²) in the Train Control / telecom cable trough / trays in the stations and depots	Supply and install C&M cables in the Train Control / telecom cable trough/tray between each substation and the nearest Station Control Room
5	SCADA requirements	Shall allocate suitable channels / bandwidth. Shall ensure smooth data flow.	Shall advise section wise SCADA requirements to Telecom Contractor Shall interface with Telecom Contractor for channel / bandwidth allocations.
6	Electromagnetic Compatibility	Shall coordinate jointly to ensure compatibility.	Shall give details of the EMC study carried out
7	Emergency Trip System (ETS) or Blue Light Station in stations, tunnels and depot	Provide emergency telephone at ETS locations (Blue Light Station locations) including telecom channel, cables etc.	<ul style="list-style-type: none"> Coordinate for location of Blue Light Stations Provide, supply and install ETS Equipment Shall provide terminals to connect ETS phone.
8	Earthing & bonding	The Traction & Telecom Contractors shall interface and coordinate for connection of the Telecom field equipment on the viaduct, in the Tunnel and on the platform to the Structure Earth Conductor. The connecting jumper cable for this shall be provided and installed by the Telecom Contractor.	Shall cooperate
T&C Stage			
9	SCADA related	Shall cooperate and associate	Shall lead the T&C related to SCADA for achieving the intended functionalities
10	ETS related	Shall cooperate and associate	Shall lead the T&C related to ETS for achieving the intended functionalities
Maintenance Stage			
11	Nil		

13.1.13 INTERFACES WITH RECEIVING SUBSTATION (RSS) CONTRACTOR

Telecom Contractor will be required to interface with the RSS Contractor, for Receiving Substation and Grid Substation.

Telecom Contractor shall provide one Direct Line Telephone connection at each of the KPTCL Grid Stations for communication from the corresponding RSSs to the KPTCL Grid Stations, similarly one direct line Telephone connection shall also be provided from the OCC to each KPTCL Grid Station.

CCTV shall also be provided by Telecom Contractor in RSS. RSS Contractor shall interface with the Telecom Contractor for necessary provision required for cable routing, location of CCTV, etc.

For providing Telecom Services in the RSS, the RSS Contractor shall provide the following items:

- Telephone cabling inside the RSS buildings to be provided by RSS Contractor
- RSS Contractor shall also provide table for providing telephone, telephone rosette with connectivity required in RSS control room
- Provision of cable trough/Trench with one bracket inside RSS boundary for laying telecom cable
- Provision of AC 230V for telecom (CCTV, CLOCK etc.) equipment

Telecom Contractor shall suitably interface for all the above items with RSS Contractor.

13.1.14 INTERFACES WITH AFC CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

No.	Item Description	Telecom Contractor	AFC Contractor
Design stage			
01	AFC data transport requirements	<ul style="list-style-type: none"> • Shall design FOTS system to accommodate transport of AFC data with LAN connections from FOTS system in CERs and TERs to AFC equipment in station and depot. Telecom does not provide LAN connections between AFC equipment at a site. Telecom data cable shall be connected on AFC data box. • Shall design IP addressing range for AFC system 	Shall provide to Telecom Contractor: IP address, TCP port, data speed and estimated traffic required by AFC between CERs and TERs for transport of AFC data. Shall provide to Telecom Contractor the demarcation locations for AFC equipment requiring LAN connection by FOTS. AFC LAN connections not requiring FOTS transport shall be by AFC.
02	CCTV for AFC equipment coverage at stations	At stations, shall design locations of CCTV cameras for coverage of AFC equipment on station concourse <ul style="list-style-type: none"> a) AFC Gate Arrays (both Entry/Exit gate arrays) b) TOM counters from outside c) TVMs 	Furnish the details and mark the same on CSDs regarding: - <ul style="list-style-type: none"> a) Gate Arrays (both Entry/Exit gate arrays) b) TOMs & EFOs c) TVMs

No.	Item Description	Telecom Contractor	AFC Contractor
03	CCTV for AFC equipment coverage at depot/OCC	<ul style="list-style-type: none"> Design the CCTV Coverage of entrances of the AFC equipment rooms furnished by AFC Contractor. Ensure the inside coverage of AFC Central Computer System Rooms and CID/CPD rooms as per the guidelines of IB. 	<p>Furnish the room locations & equipment layouts of:</p> <ul style="list-style-type: none"> a) AFC Central System Rooms b) CID/CPD Rooms c) SDC Room d) AFC Repair Lab
04	Access Control and Intrusion Detection	<p>Shall design ACID to accommodate the tamper detectors on</p> <ul style="list-style-type: none"> a) Station TOM/EFO Rooms b) AFC Central System Rooms, CID/CPD Rooms, SDC Room and AFC Repair Lab at OCC, BCC & Depots. 	<p>Shall provide locations of AFC Equipment rooms at stations, depots, OCC and BCC (if it is in the part of telecom Contract)</p>
05	Master clock (Time Distribution System)	<p>At depot, shall design TDS to provide NTP to AFC equipment</p> <p>Telecom Contractor shall design equipment & software for printing photo ID on AFC supplied cards</p>	<p>Shall provide to Telecom Contractor the requirements for NTP (TDS connection)</p> <p>AFC Contractor shall supply technical specifications of photo ID, AFC compatible cards for BMRCL staff</p>
06	Detailed Interface Document (Telecom & AFC)	<p>Prepare and Sign-off "Detailed Interface Document (Telecom & AFC)" with AFC Contractor and submit to Employer</p>	<p>Review and sign-off Detailed Interface Document (Telecom & AFC) with Telecom Contractor</p>
C&I stage			
07	Provision of Communication channel for Implementing WAN for AFC System	<ul style="list-style-type: none"> a) At Stations – Configure AFC VLAN on GE ports earmarked for AFC as per DID b) At Depot/OCC/BCC – Configure AFC VLAN on core switch/server farm GE ports earmarked for AFC as per DID 	<ul style="list-style-type: none"> a) At Stations – Lay cables and connect to ethernet ports designated for AFC on Telecom GE switch. b) At Depot/OCC/BCC – Lay cables and connect to ethernet ports designated for AFC on Telecom GE core switch/server farm.
08	CCTV coverage at stations	<p>Shall install CCTVs to ensure coverage of: -</p> <ul style="list-style-type: none"> a) Gate Arrays (both Entry/Exit gate arrays) b) TOMs & EFOs c) TVMs 	<p>Shall coordinate and ensure CCTV coverage of</p> <ul style="list-style-type: none"> a) Gate Arrays (both Entry/Exit gate arrays) b) TOMs & EFOs c) TVMs
09	CCTV coverage for AFC equipment at depot/OCC	<ul style="list-style-type: none"> Provide the CCTV Coverage for entrances of the AFC equipment rooms furnished by AFC Contractor. Ensure the inside coverage of AFC Central Computer System Rooms and CID/CPD rooms as per the guidelines of IB. 	<p>Ensure the CCTV Coverage of: -</p> <ul style="list-style-type: none"> a) AFC Central System Rooms – Entrances & Inside Room b) CID/CPD Rooms – Entrances & Inside Room c) SDC Room – Entrance d) AFC Repair Lab – Entrance

No.	Item Description	Telecom Contractor	AFC Contractor
10	Access Control and Intrusion Detection (If it is part of Telecom Contract)	Install ACID system to accommodate the tamper detectors on a) Station TOM/EFO Rooms b) AFC Central Computer System Rooms, CID/CPD Rooms, SDC Room and AFC Repair Lab at OCC, BCC & Depots.	Shall coordinate the ACID installation at AFC equipment rooms at Stations, Depots, OCC and BCC
11	Master Clock Synchronization	Configure and provide main and redundant NTP server Ips for AFC Equipment.	Configure NTP server Ips in AFC Equipment
T&C stage			
12	Network connectivity	Shall jointly test network connectivity and bandwidth provisions between AFC equipment at stations, OCC, BCC and Depots with AFC Contractor.	Shall jointly test network connectivity and bandwidth provisions between AFC equipment at stations, OCC, BCC and Depots with Telecom Contractor.
13	CCTV coverage at stations	At stations, shall jointly test views by CCTV cameras in stations required by AFC	At stations, shall verify views by CCTV cameras in stations required by AFC
14	CCTV coverage at depot	At depot, shall jointly test CCTV cameras' view required by AFC.	At depot, shall verify views by CCTV cameras in AFC Equipment Rooms
Maintenance stage			
15		Nil	Nil

13.1.15 INTERFACES WITH LIFT & ESCALATOR CONTRACTORS

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item no.	Item	Telecom Contractor	Elevator (Lift) / Escalator Contractor
1	Lift phone	Shall make provision for connecting lift phone in EPABX / Call Server for extending intercom	<ul style="list-style-type: none"> Shall make the provision for intercommunication system between SCR & Lift Controller. Shall coordinate with Telecom Contractor and lay cables to TER through cable trays. Shall coordinate with Telecom Contractor for interconnections in the SCR.

13.1.16 INTERFACES WITH TRACK CONTRACTORS

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item no.	Item	Telecom Contractor	Track Work (TRW) Contractor
1	Track crossing of cables	Shall provide all track crossings details including pipes and support and/or drilling of holes in the plinth	Shall provide cut-outs/pipes in the track plinth on ballast less tracks, at regular intervals as per design
2	Installation of trackside equipment (radio masts)	Shall furnish the final size of trackside equipment's and co-ordinate with Track Contractor(s) to ensure the compliance of schedule of dimensions. All mechanical fixtures, fitting arrangement etc. for trackside equipment shall be provisioned by Telecom Contractor.	Shall co-ordinate with Telecom Contractor to ensure the compliance of schedule of dimensions.

13.1.17 INTERFACE WITH TVS CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Telecom Contractor	TVS Contractor
	Design Stage		
1	TVS SCADA cable interface	Shall coordinate the location of TER room for termination of TVS SCADA cables into Ethernet Switch.	Provision of RTUs at station TER room for termination of TVS SCADA cables from TVS control panels in stations
2	Optic fiber network	To provide the fiber-optic from TER to OCC/BCC. Shall design the telecom connectivity arrangements between different stations and the OCC including the required communication switches at the CER to meet TVS requirements	Shall advise the details of connectivity required between different stations and the OCC for connecting the HMI and PLC's at different sites
3	TVS SCADA connectivity	Shall advise the location of communication switches and the inter connectivity hardware details to the TVS Contractor for Connecting the TVS SCADA system	Shall plan for necessary cabling from the location of communication switches to the workstations and PLC's for TVS
4	Bandwidth requirement	Design guaranteed bandwidth required by TVS Contractor between various locations (stations and OCC/BCC). Quality of service (QoS) shall be appropriately designed.	Furnish bandwidth requirement between various locations (stations and OCC/BCC)
5	Data Communication requirements	Shall design as per the TVS requirements:	Shall furnish the requirements of:

Item No.	Subject	Telecom Contractor	TVS Contractor
		<ul style="list-style-type: none"> Data connectivity between various locations IP's/VLAN requirement. Redundancy requirement. Bandwidth requirement 	<ul style="list-style-type: none"> Data connectivity between various locations IP's/VLAN requirement. Redundancy requirement. Bandwidth requirement
6	GE & TVS interconnectivity design	Design interconnection between TVS switches & GE switches, at station level & at OCC level with redundancy & appropriate protocol so that no single point of failure will affect the TVS communication to OCC/BCC	Shall coordinate with Telecom Contractor for suitable protocol implementation in TVS Ethernet switches to ensure redundancy as specified under the scope of telecom Contractor under this point
7	TVS data transport requirements	Design and make provision for TVS System: - <ol style="list-style-type: none"> Assign VLANs & IP Addresses for stations, depots, OCC and BCC as per the requirements furnished by TVS Contractor. Assign the Ethernet ports at stations, depots, OCC and BCC as per the requirements furnished by TVS Contractor. Make provision for bandwidth through QoS or otherwise as per the TVS Contractor's requirement. 	Furnish the requirements of: - <ol style="list-style-type: none"> VLANs & IP Addresses for each location, including stations, depots, OCC and BCC. Ethernet ports requirement for each location including stations, depots, OCC, BCC. Bandwidth requirement between different locations including Stations to OCC, Stations to BCC, OCC to BCC.
8	Location of TVS switches at TER room	Allocate suitable location in TER room for the TVS switch rack	Shall coordinate for the location in TER room for TVS switch rack
9	Cable routing details at TER room /OCC	Suggest suitable cable routing options to TVS Contractor within TER	Design cable routing path for TVS cables as per Telecom Contractor suggestions
C&I Stage			
10	All relevant issues	Shall coordinate appropriately to ensure the agreed requirements are implemented	Shall construct and install the TVS system as per the agreed designs
11	TVS SCADA connectivity	Shall provide the telecom connectivity arrangements between different stations and the OCC including required communication switches at the CER to meet the necessary control and monitoring requirements of TVS	Shall coordinate
12	TVS SCADA installation at OCC	Shall coordinate	Shall install TVS SCADA system at OCC theatre and the intra-site cabling from the communication switches up to the PLC's of the TVS
13	Data exchange between E&M and TVS SCADA systems	At the OCC, shall install suitable interfacing arrangements at the E&M SCADA end and provide	At the OCC, shall install and wire the interface device (between E&M SCADA system and TVS SCADA

Item No.	Subject	Telecom Contractor	TVS Contractor
		cable connection up to the interface device of TVS SCADA system for exchange of high-level alarms	system) at the TVS SCADA system end for exchange of high-level alarms
14	Network connectivity	Shall jointly test network connectivity and bandwidth provisions between TVS equipment at stations, OCC, BCC and Depots with TVS Contractor.	Shall jointly test network connectivity and bandwidth provisions between TVS equipment at stations, OCC, BCC and Depots with Telecom Contractor.
15	Data Communication requirements	Shall configure as per the TVS requirements: <ul style="list-style-type: none"> • Data connectivity between various locations • IP's/VLAN requirement • Redundancy requirement • Bandwidth requirement 	Shall coordinate
16	Bandwidth requirement	a) At Stations – Configure TVS VLAN on GE ports earmarked for TVS as per DID b) At Depot/OCC/BCC – Configure AFC VLAN on core switch/server farm GE ports earmarked for TVS as per DID	a) At Stations – Lay cables and connect to Ethernet ports designated for TVS on Telecom GE switch. b) At Depot/OCC/BCC – Lay cables and connect to Ethernet ports designated for TVS on Telecom GE core switch/server farm.
17	Location of TVS switches at TER room	Shall coordinate and check the installation is as per agreed location	Shall install the TVS switch rack at the agreed location as per the design
18	Cable routing details at TER room /OCC	Shall coordinate and check the installation is as per agreed location	Shall lay the cable between PLC to TVS switches & TVS switches to GE switches as per the agreed route in the design; Label all cables
T&C Stage			
19	System functional testing	Shall attend the joint functional test and validate the results and produce the document to the client. The test should be carried out comprising bandwidth availability checks, speed of the data checks, redundancy checks between GE switches & TVS switches (station & OCC/BCC)	<ul style="list-style-type: none"> • Shall jointly test all call functional requirements of the switches and ensure the control and monitoring arrangements of TVS between the OCC and different UG stations. • Test TVS controlling & monitoring functionality with various test cases related with telecom system
20	System testing between E&M and TVS SCADA systems	Shall attend the joint test and validate the results	Shall jointly test the monitoring of high-level alarms of the TVS SCADA by M&E SCADA system
O&M Stage			
21	Procedure	Prepare the joint maintenance procedures and any issues raised regarding communication by TVS Contractor should be addressed.	<ul style="list-style-type: none"> • Periodicity of joint inspection regarding the working of inter station data connectivity through CBN, Inter station data connectivity through the CBN, intra site

Item No.	Subject	Telecom Contractor	TVS Contractor
			LAN network and the monitoring of high levels alarms of TVS SCADA system. <ul style="list-style-type: none"> Any issues raised due to communication should be informed to Telecom Contractor. Validate the joint maintenance procedure document prepared.

13.1.18 INTERFACE WITH ECS CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Telecom Contractor	ECS Contractor
	Design Stage		
1	Equipment heat load	Provide telecommunication equipment heat loads	Design of ECS provision in Telecom equipment room, CDMA room & security room.
2	Layout design	Coordinate with ECS on location of FCUs, piping and ductworks in Telecom equipment room	Prepare design and location of FCUs, piping and ductworks in telecom equipment room
3	ECS system design input data	Shall furnish the details of equipment heat generation load, number of persons and Ventilation or Air conditioning requirement from Telecom system equipment rooms to design the ECS system in all underground stations	Shall take into account the details of equipment heat generation load, number of persons and Ventilation or Air conditioning requirement to design the VAC system in all underground stations
4	E&M and ECS SCADA system interfaces	Shall design the E&M & ECS SCADA system and telecom connectivity arrangements between the M& E SCADA System and interface device of ECSSCADA of the station to facilitate monitoring of Underground ECS system operations and high-level alarms from the OCC, through the M & E SCADA System	Shall advise the location of interface device at the station level
5	Station BMS	Shall provide the telecom connectivity arrangements at different stations and the OCC to meet the monitoring requirements of the ECS system, through the TVS SCADA at the OCC	Shall install and write the interface device at station level to meet the necessary monitoring requirements of the ECS system from the OCC TVS SCADA
	C&I Stage		
6	Construction and installation stage	Shall provide the telecom connectivity arrangements at different stations and the OCC to meet the monitoring	Shall install and write the interface device at station level to meet the necessary monitoring requirements of the ECS system from the OCC M&E SCADA.

Item No.	Subject	Telecom Contractor	ECS Contractor
		requirements of the ECS system, through the M&E SCADA at the OCC.	
7	ECS SCADA installation	Shall monitor and Co-ordinate	Shall install ECS SCADA system and IBP at SCR including cabling of ECS system
8	ECS installation	Shall monitor	Shall install the ECS system in SCR, SER, CER and TC
9	Station BMS	Cable from ECS RTU at station TER room to Telecom equipment To provide the fiber optic from TER to OCC	Provision of RTUs at station TER room for termination of BMS cables
T&C Stage			
10	System functional testing	Shall attend the joint functional test and validate the results and produce the document to the client. The test should be carried out comprising bandwidth availability checks, speed of the data checks, redundancy checks between GE switches & ECS switches (station & OCC/BCC)	<ul style="list-style-type: none"> Shall jointly test all call functional requirements of the switches and ensure the control and monitoring arrangements of ECS between the OCC and different UG stations. Test ECS controlling & monitoring functionality with various test cases related to telecom system.
11	System testing	Shall attend and verify the ECS parameters such as temperature and relative humidity in telecom system equipment rooms at all underground stations	Shall conduct joint testing on ECS system in telecom system equipment rooms at all underground stations
12	Installation Test document	Shall carryout the joint testing for the cable and ECS switches installation as per the agreed design. Mutually signed off installation test document shall be submitted for Employer's review	Shall coordinate and mutually signed off installation test document shall be submitted for Employer's review
O&M Stage			
13	Procedure	Finalize the joint maintenance procedures and periodically of joint inspection between Telecom and ECS system and include the same in the Telecom system maintenance manual	Shall validate the joint maintenance procedures and test plans prepared Telecom Contractor

13.1.19 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 5.1.11 above](#) shall apply as relevant to the context

13.1.20 INTERFACE WITH PSD/PSG CONTRACTOR

13.20.1. DEFINITIONS AND INTRODUCTION

13.20.1.1. This specification covers the interface requirements between PSD/PSG Contractor and Communication Contractor.

- 13.20.1.2. In this Specification, unless otherwise stated, the term “Contracts” refers to all the relevant Contracts and the term “Contractors” refers to all the relevant Contractors. The individual Contractors are referred to by the corresponding Contract number.
- 13.20.1.3. This document shall be read in conjunction with the relevant paragraphs of the General Specification. The Contractors shall ensure all requirements of the General Specification and Technical Specification pertaining to interfaces are fully resolved and implemented.
- 13.20.1.4. In the event of a conflict between the Technical Specification specified elsewhere and the details specified herein, the requirements specified herein shall prevail.
- 13.20.1.5. This specification outlines the Contractors’ interface requirements, which are based on the Technical Studies carried out during the early stages of the Project. However, the requirements herein specified are by no means exhaustive and it remains the Contractors’ responsibilities to develop, update and execute jointly Interface Management details during design & throughout the execution of Works, to ensure that:
- All interface issues between the Contracts are satisfactorily resolved
 - Design, supply, installation, and testing of equipment are fully coordinated
 - All equipment and facilities supplied under the Contracts are fully compatible with each other, whilst meeting the requirements of the respective Specifications.

13.20.2. Scope of work

Sl. No.	Purpose / Subject of interface	Communication Contractor	PSD/PSG Contractor
1.	CCTV activation due to Alarms on PSD/PSG	<ul style="list-style-type: none"> Upon receiving the alarm from PSD/PSG system, CCTV shall display the camera view mapped the that particular PSD/PSG. Above stated camera based on alarm received should be done in that particular station SCR & SECR along with OCC and BCC relevant terminals, and Security surveillance rooms in BMRCL Network. 	<ul style="list-style-type: none"> An alarm shall be sent to the CCTV system for activation of the Video display in SCR/OCC/BCC/Security Rooms whenever PSD/PSG system detects obstruction of the affected door/platform.

Sl. No.	Purpose / Subject of interface	Communication Contractor	PSD/PSG Contractor
2.	CCTV activation due to Train Undershoot/Overshoot at Platform	<ul style="list-style-type: none"> Upon receiving the trigger/Signal from the signaling system at OCC and BCC, the Communication system (CCTV) shall display the video of the platform location of that particular station in SCR, SECR, and relevant CCTV HMI's at OCC and BCC including Security surveillance room at OCC & BCC. 	<ul style="list-style-type: none"> Whenever, there is an event of Undershoot/overshoot by a Train, a signal/trigger from signaling system shall be sent to the communication system (CCTV) at OCC and BCC, to trigger CCTV video display for displaying those particular cameras on CCTV HMI in SCR/OCC/BCC and Security surveillance room wherever necessary.
3.	GPS synchronized clock system	<ul style="list-style-type: none"> Shall provide the GPS-synchronized clock signal to the PSD/PSG system. 	<ul style="list-style-type: none"> Shall synchronize the internal system clock of the PSD/PSG system with the clock system.

CHAPTER 14

14.0 POWER SUPPLY SYSTEM INTERFACES

14.1.1 INTERFACES WITH ELEVATED CIVIL CONTRACTORS

Refer to [Para 2.1.8 above](#)

14.1.2 INTERFACES WITH UG CIVIL CONTRACTORS

Refer to [Para 3.1.8 above](#)

14.1.3 INTERFACES WITH DEPOT CIVIL CONTRACTORS

Refer to [Para 4.1.8 above](#)

14.1.4 INTERFACES WITH ELEVATED E&M CONTRACTORS

Refer to [Para 5.1.5 above](#)

14.1.5 INTERFACES WITH UG E&M CONTRACTORS

Refer to [Para 6.1.5 above](#)

14.1.6 INTERFACES WITH DEPOT E&M CONTRACTORS

Refer to [Para 7.1.6 above](#)

14.1.7 INTERFACES WITH ELEVATED FINISHING WORKS CONTRACTORS

Refer to [Para 8.1.5 above](#)

14.1.8 INTERFACES WITH UG FINISHING WORKS CONTRACTORS

Refer to [Para 9.1.5 above](#)

14.1.9 INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS

Refer to [Para 10.1.6 above](#)

14.1.10 INTERFACES WITH S&TC CONTRACTOR

Refer to [Para 11.13 above](#)

14.1.11 INTERFACES WITH RS CONTRACTOR

Refer to [Para 12.1.9 above](#)

14.1.12 INTERFACES WITH TELECOM CONTRACTOR

Refer to [Para 13.1.12 above](#)

14.1.13 INTERFACES WITH RECEIVING SUBSTATION (RSS) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Item Description	PST Contractor	RSS Contractor
1	Supply and Installation of 33kV panels, Transformer, DC equipment Panels, RTU and other traction equipment etc. of ASS/TSS in RSS	<ul style="list-style-type: none"> Shall share the requirement for installation of equipment in the RSS including sizes and weight of the equipment for designing the room sizes and flooring. Shall coordinate, supply and install 33kV cable from the secondary of the Power Transformers to 33kV switchgear at RSS. Shall supply, install, testing and commissioning of 33kV switchgears, 33kV cables, Auxiliary and Traction Transformers, 750V DC equipment, Panel Fire Protection equipment, RTU and SCADA. 	<ul style="list-style-type: none"> Shall design and accommodate the requirements for installation of equipment in compliance with the building codes, standards and statutory requirements. Shall coordinate and suitably design the secondary terminals of the power transformer for connection of 33kV Cables. Design and construct the rooms and floors with required electrical and mechanical services accordingly. Shall provide access to Contractor for installation, testing and commissioning of the equipment.
2	Installation of Cable support/ Trays/hangers at RSS	<ul style="list-style-type: none"> Shall share the cable schedule with sizes, weight, voltage grade, bending radius etc., for design of cable trays within RSS. 	<ul style="list-style-type: none"> Shall design cable trench, duct and other cable support infrastructure including cutout sealing to accommodate the requirements of Traction Contractor.

Item No.	Item Description	PST Contractor	RSS Contractor
		<ul style="list-style-type: none"> Shall coordinate for any cut out/opening required for equipment/cable laying. Shall supply, install, testing and commissioning of the cables with terminations. Shall supply and install all 33kV/SCADA/ protection cables from 33kV panel at RSS to nearest station ASS/ TSS. The cable brackets, hangers, trays etc., from RSS boundary to nearest ASS/TSS shall be under the scope of PST Contractor. 	<ul style="list-style-type: none"> Shall construct cable ducts/trench, supply and install the cable support infrastructure like cable trays, raceways, etc. for the requirement of traction Contractor within the boundary of RSS. Shall design and construct the cable trench/duct form RSS boundary to nearest ASS/TSS. Shall close the opening with fire stops after installation of the LT cables/cable trays.
3	Data exchange cable between GSS and RSS	<ul style="list-style-type: none"> Shall provide the approved list of data/information to be exchanged with PSA Shall coordinate to lay and terminate the communication cable. 	<ul style="list-style-type: none"> Shall coordinate and confirm with traction Contractor regarding the details of data exchange cable Shall procure and lay the communication cable or data exchange cable.
4	SCADA	<ul style="list-style-type: none"> Shall design, supply, Installation testing and commissioning of RTU at RSS and SCADA (RTUs, Server, Workstations. LVDS at OCC, LED/Video display units at RSS etc.) complete in consultation with RSS Contractor including the requirement and status monitoring of the equipment at PSA side and all the 66kV and 33kV equipment supplied and installed by RSS Contractor Shall co-ordinate with RSS Contractor for the control and monitoring requirements of RSS equipment installed by Power supply Contractor as well as status monitoring of the equipment at PSA side. Shall further connect and coordinate and provide status, alarm at operator workstation of SCADA in LCC/ OCC/BCC for 66kV and 220kV equipment supplied by RSS Contractor including PSA side equipment. Shall be the custodian for RTU and responsible for complete integration of all equipment of RSS 	<ul style="list-style-type: none"> Shall share the I/O details, and coordinate for the approved final list of data/information identified for exchange through SCADA. Shall terminate all I/O signals at PCU/Marshaling box pertaining to the scope of RSS Contractor. PCU shall be compatible for communication with RTU over IEC 61850 protocol. Shall be responsible for connecting all I/O signals in a compatible form up to RTU including all the required cables, connector, wires terminations etc. Shall demonstrate the functioning of all the equipment (supplied under the scope of RSS Contractor) locally at RTU level in close coordination with Traction Contractor and shall support with PST Contractor for local and integrated SCADA testing. Shall coordinate for equipment layout in control room for SCADA related equipment including RTUs, servers, Workstations and LED/Video display units etc.

Item No.	Item Description	PST Contractor	RSS Contractor
		and PSA side signals and data connectivity to OCC. <ul style="list-style-type: none"> • Shall carry power and control cabling from PCU/Marshaling box to RTU. • Shall coordinate and share the requirements for the equipment layout and related interfaces of RTUs, servers, Workstations and LED/Video display units. • Shall share the MET requirements for RTU and SCADA equipment. 	<ul style="list-style-type: none"> • Shall provide cable trenches/cable support inside the RSS Building for SCADA work related Cables. • Shall provide MET to facilitate earthing of SCADA equipment by PST Contractor. • Shall incorporate power supply requirements of SCADA equipment for sizing of UPS and battery charger. • Shall coordinate or the approved final list of data/information identified for exchange through SCADA
5	Lighting and ventilation in RSS	<ul style="list-style-type: none"> • Shall provide heat load for electrical equipment inside RSS • Shall interface for any special requirements or preferred locations of lights, ventilation/ exhaust fans and any other power requirement. 	<ul style="list-style-type: none"> • Shall design and provide adequate ventilation and lighting system including ventilation/ exhaust fans, power sockets. • Shall provide cable connection from MDB/DB to switching panels of ventilation/exhaust fans
6	Connection (Bus duct) from Traction transformer secondary to Rectifier	<ul style="list-style-type: none"> • Shall design, supply, terminate and install cable/bus-duct connection from traction transformer secondary to Rectifier including the necessary supports required for installation. 	<ul style="list-style-type: none"> • Shall accommodate and accordingly design the equipment layout land other building services
7	Connection (Bus duct) from Transformer to MDB	<ul style="list-style-type: none"> • Shall design, supply, terminate and install bus-duct connection from Auxiliary transformer secondary to MDB including the necessary supports required for installation. 	<ul style="list-style-type: none"> • Shall accommodate and accordingly design the equipment layout land other building services
8	Protection system	<ul style="list-style-type: none"> • Shall coordinate for achieving the complete protection requirements between Power transformers and 33kV distribution system. • Shall suitably interface for the required CT ratios, Characteristics etc., required in 33kV switchgear in incoming feeders from Power Transformers and accordingly supply and install the required CTs for achieving Protection Philosophy. 	<ul style="list-style-type: none"> • Shall interface and share the protection requirements envisaged at 33kV switchgear incoming feeders from Power Transformer such as Transformer Differential protection, over current protection etc.
	Note: A joint protection design interface document (DID) shall be developed by RSS Contractor in coordination and consultation with PST Contractor, jointly signed by both shall be submitted for Engineer's Approval. The said protection DID shall address the combined approach of achieving the combined protection philosophy.		

Item No.	Item Description	PST Contractor	RSS Contractor
9	Earthing in RSS	<ul style="list-style-type: none"> Shall integrate the designs of earth mat and other parameters into the combined earthing and bonding plan. Shall associate during the installation of earth mat and jointly witness for the combined resistance measurement of the earth mat after installation. Shall supply, install and connect various equipment to Earth Bus/METs with G.I./Copper strips inside switchgear room and wherever required for the equipment and cables supplied and installed by PST Contractor. Shall be the custodian and integrator of earthing and bonding system of RSS, depot and mainline. 	<ul style="list-style-type: none"> Shall measure soil resistivity and design Earth mat in coordination with PST Contractor. Shall install, test and commission earth mat according to approved design. Shall install Earth Bus / METs (main earth terminals connected to the earth mats) inside switchgear rooms, outdoor yard and wherever required for the equipment and cables supplied and installed by PST Contractor to facilitate the connection of equipment.
10	110V DC control supply and DCDB	<ul style="list-style-type: none"> Shall coordinate for the required 110V DC feeders from DCDB. Shall supply and install 110V DC Cable from the designated feeder of DCDB to the equipment supplied and installed by PST Contractor. Shall coordinate for cable support from DCDB to equipment. 	<ul style="list-style-type: none"> Shall supply, install, test and commission 110V DC Battery, Battery charger and DCDB. Shall provide the required 110V DC feeder. Shall Supply and Install cable support from DCDB to equipment of PST Contractor. Shall supply and install 110V DC Cable from the designated feeder of DCDB to the equipment supplied and installed by RSS Contractor.
11	415/230V AC auxiliary supply and MDB	<ul style="list-style-type: none"> Shall coordinate and interface for feeders required from MDB (refer note below) Shall supply and install 415/230V AC Cables from the designated feeder of MDB to the equipment supplied and installed by PST Contractor. Shall coordinate for cable support from MDB to equipment. 	<ul style="list-style-type: none"> Shall coordinate and interface for feeders required from MDB (refer note below) Shall supply and install 415/230V AC Cable support from the designated feeder of MDB to the equipment supplied and installed by PST Contractor. Shall provide 230V AC UPS feeders.
	Note: Design, supply, installation, testing and commissioning of 415V MDB and DG set at RSS located inside depot is under the scope of depot E&M Contractor. The RSSs located outside depot i.e. Nagawara& Silk Board, supply, installation, testing & commissioning of DG set is under scope of PST Contractor.		
12	Temporary Power for Installation, testing & commissioning.	<ul style="list-style-type: none"> Shall co-ordinate with RSS for provision of temporary power supply. Shall advise temporary power demand & required capacity and provide temporary cable. 	<ul style="list-style-type: none"> Shall provide sockets for availing temporary power, at main DB or if available, inside ASS/TSS rooms as per requirement Shall provide suitable meters for calculating the consumption

Item No.	Item Description	PST Contractor	RSS Contractor
		<ul style="list-style-type: none"> Shall install the required DB with all safety features for availing the temporary power. Shall pay to the RSS Contractor for the power consumption. Note: If temporary power is not available at RSS, then PST Contractor shall make his own arrangement. 	

14.1.14 INTERFACES WITH TRACK WORK (TRW) CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item no.	Purpose of Interface	Power Supply & Traction (PST) Contractor	Track work (TRW) Contractor
	Design Stage		
1	Track alignment	Shall produce the detailed third rail layout plan including details of all support assembly	Provide track alignment, track slab layout and final alignment of tracks in depot showing all the sleepers
2	Third Rail (Mainlines and Depots)	<ul style="list-style-type: none"> Shall confirm the design of the third rail assembly including all components and as per the specifications Also, to confirm the position of dowels to be embedded by track work Contractor during casting of third rail pedestal 	Shall make suitable arrangements for installation supports for 3rd rail equipment i.e. embedding of dowels at specified locations
3	750 V DC Cables and connections	Shall furnish requirements of cable crossings through track plinths/slabs for mainlines and depots (for both ballasted and non-ballasted tracks)	Shall design appropriate means for track crossings of the cables at the desired locations
4	Return cable connections	Shall provide details of holes required in rails for connection of return cables	Shall consider the requirement of PST Contractor.
5	Rails and Track cross bonds and bonding at turnouts, points and crossings	Shall provide details of holes required in tracks for connecting the bonds	Shall consider the requirement of PST Contractor.
6	Earthing, bonding and stray current protection measures	<ul style="list-style-type: none"> Shall provide schematics and For-construction drawings of earthing, bonding and stray current protection 	<ul style="list-style-type: none"> Shall consider the requirements in the design of track structure

Item no.	Purpose of Interface	Power Supply &Traction (PST) Contractor	Track work (TRW) Contractor
		<ul style="list-style-type: none"> Shall provide schematics and For-construction drawings of stray current mitigation rebar arrangements in the track slab 	<ul style="list-style-type: none"> Shall prepare construction structure drawings of track slab/plinth as get it agreed / approved by PST Contractor
7	Insulated Rail Joints (IRJ) between main line and the depot line	Shall provide details of locations where IRJs are required to be installed for traction power requirements.	Shall consider the requirement of PST Contractor in the track design
	C&I Stage		
8	Third Rail (Mainlines and Depots)	<ul style="list-style-type: none"> Shall procure dowels and jigs and shall supply the same to the Track Contractor free of cost at site for installation / embedding of the dowels Shall install third rail equipment along with its accessories Dowels to be supplied by PST contractor 	<ul style="list-style-type: none"> Shall coordinate and embed the dowels in track structure as per the design Also, to confirm the position of dowels to be embedded by track work contractor during casting of third rail pedestal.
9	750 V DC Cables and connections	<ul style="list-style-type: none"> Shall supply, and install 750 V DC cables along with lugs and accessories at either end, i.e. including connecting cables to power feed assemblies of the 3rd rail system. Shall coordinate with the TRW Contractor for availability of suitable track crossings at the desired locations for 750 V DC cables, return cables and 33 kV cables (for stations, mainlines and depot tracks). In case of any specific additional requirement, PST Contractor shall indicate the requirement and shall provide necessary pipes for providing the same under the track. 	<ul style="list-style-type: none"> Shall coordinate Shall provide appropriate means for track crossings of the cables at the desired locations inclusive of installing the HDPE / PVC pipes (supplied by PST Contractor) where necessary.
10	Return cable connections	Shall connect return cables to rails including all hardware and accessories required for the connections	Shall drill holes in rails as per requirement of PST Contractor.
11	Rails and Track cross bonds and bonding at turnouts, points and crossings	Shall supply and install cross bonds and other bonds on track	<ul style="list-style-type: none"> Shall allow PST Contractor to install track cross bonds and other bonds Shall drill holes in the rails as per requirement of PST Contractor
12	Earthing, bonding and stray current protection measures	<ul style="list-style-type: none"> Shall witness the track to structure conductance measurement 	<ul style="list-style-type: none"> Shall install the stray current collection mitigation rebars in track slabs

Item no.	Purpose of Interface	Power Supply & Traction (PST) Contractor	Track work (TRW) Contractor
		<ul style="list-style-type: none"> Supply and connect the 70 mm² copper cable to the Structure Earth Cable from MS strip on track plinth slab at girder ends (pier locations) 	<ul style="list-style-type: none"> Shall provide rail insulation to ensure adequate insulation (as per design) of rails / tracks from structure Shall perform track to structure conductance measurement as per EN 50122-2 Supply and install connecting plate at every slab end to ensure electrical continuity by providing GS flat at each end of the slab for connection with 70 mm² copper cables.
13	Insulated Rail Joints (IRJ) between main line and the depot line	Shall associate and cooperate	Shall supply and install the IRJs to the requirement of PST Contractor.
	T&C Stage		
14	Third Rail (Mainlines and Depots)	<ul style="list-style-type: none"> Shall perform post installation tests and shall ensure that the installation tolerances are within limits and touch voltages are in accordance with the requirements of EN 50122, and conform to the requirements of IEC 479. The correctness of usage of touch to be confirmed. Provide As-built installation drawings of third rail sections. 	Shall associate with PST Contractor for post installation tests
	Maintenance Stage		
15	Nil		

14.1.15 INTERFACES WITH M&P CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item no.	Purpose of Interface	Power Supply & Traction (PST) Contractor	M&P Contractor
1	Instrumented Third Rail Maintenance Vehicle	Share the details / drawings of the Third Rails and its layout as required	Coordinate with PST Contractor for information sharing and progressing the work
2	Multi-functional work station	Share the details / drawings of the Third Rails and its layout as required	Coordinate with PST Contractor for information sharing and progressing the work
3	Automatic Train wash plant	Isolate the third rail as per M&P contractor	Provide the GAD.
4	Pit Wheel lathe	Isolate the third rail as per M&P contractor	Provide the GAD.

14.1.16 INTERFACE WITH TVS CONTRACTOR

Not applicable

14.1.17 INTERFACE WITH ECS CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Power Supply & Traction (PST) Contractor	ECS Contractor
	Design Stage		
1	Inputs for ECS system design in PST equipment rooms	Shall provide the details of equipment heat generation load, number of persons and Ventilation / Air Conditioning requirements in the UG station power supply such as ASS & TSS Rooms to design Station ECS System	Shall get the details of equipment heat generation load, number of persons and Ventilation / Air Conditioning requirements in the UG station power supply such as ASS & TSS Rooms to design Station ECS System
2	ECS system design in equipment room	<ul style="list-style-type: none"> • Provide layout of equipment in ASS & TSS • Shall coordinate 	<ul style="list-style-type: none"> • Layout of ECS ductworks and grille/diffuser positions with respect to equipment layout • Shall install ECS equipment in the Power supply system technical rooms such as ASS & TSS Rooms
	C&I Stage		
3	System installation	Shall coordinate appropriately	Shall install the ECS system as per agreed and approved designs
	T&C Stage		
4	System testing	Shall co-ordinate with Contractor and confirm	Shall jointly check the VAC parameters such as Temperature and Humidity in the Power supply and Traction rooms
	O&M Stage		
5	ECS system O&M	Shall cooperate and support the O&M activities as relevant	Shall lead the O&M activities of the ECS system

14.1.18 INTERFACE WITH PSD/PSG CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item no.	SUBJECT	POWER SUPPLY & TRACTION (PST) Contractor	PSD/PSG Contractor
1	Earthing of Outdoor PSG/PSD equipment.	PST contractor shall provide Buried Earth conductor (BEC) for earthing of PSD equipment. PST contractor shall finalise the connection of PSD to running rail or to structure earth during detailed design stage.	PSG/PSD contractor to connect the PSD equipment to either station earth (both end) or to running Rails as decided during detailed design stage with PST contractor. Complete earthing arrangement from structure bolt along with connecting accessories (such as clamps) to be arranged by PSD frames. If PSD equipment to be connected to running rails, then location to connect returns rails shall be from nearest path from PSD.
2	Design, Supply and Works for Insulation of PSD/PSG frames from structure earth.	Shall interface with PSD contractor to ensure insulation of PSD/PSG frames from structure earth.	Shall provide the Insulation of PSD/PSG frames from structure earth/surface/re-bars/reinforcement etc.
3	Insulation of PSD/PSG frames from structure earth	Shall witness and verify the insulation test conducted by PSD contractor.	Shall carry out insulation test for PSD frame according to the applicable standards.
4	Platform Insulation at Stations	Shall provide the insulating membrane at station platform.	Insulation of frame to be done by PSD contractor. Shall coordinate with PST contractor & station civil for leaving the area where PSD frame to be installed. Balance platform insulation will be carried out by PST contractor.

14.1.19 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 5.1.11 above](#) shall apply as relevant to the context

CHAPTER 15

15.0 RSS CONTRACTOR'S INTERFACES

15.1.1 INTERFACES WITH DEPOT CIVIL CONTRACTORS

Refer to [Para 4.1.9 above](#)

15.1.2 INTERFACES WITH DEPOT E&M CONTRACTORS

Refer to [Para 7.1.7 above](#)

15.1.3 INTERFACES WITH TELECOM CONTRACTORS

Refer to [Para 13.1.13 above](#)

15.1.4 INTERFACES WITH PST CONTRACTORS

Refer to [Para 14.1.13 above](#)

15.1.5 INTERFACES WITH TRACTION DDC

BMRCL has appointed a DDC (Detailed Design Consultant) Traction & Power Supply for Extension lines and for new lines (Reach 5 and Reach 6). The DDC Contract involves detailed design for the Power Supply Distribution System, 750 V DC, Third Rail Traction Electrification and SCADA System for the Project.

The RSS Contractor will be required to interface with the DDC (Traction)/BMRCL for any design / design review related issues, technical clarifications and/or confirmations.

15.1.6 INTERFACES WITH GOVERNMENT AGENCIES

The RSS Contractor shall be required to interface with various Government Agencies for successful execution of the work. The interface issues shall include but not limited to following:

- Obtaining all permission from road agency and other agencies for digging along road/pavements as necessary.
- Restoration of sites, roads as required under the local laws.
- Interface with Telecom authorities, Gas Distribution Authorities and other agencies to ensure that functioning of the utilities is not jeopardized by the actions of the Contractor
- Interface including all documentation, coordination and necessary tests for obtaining statutory approval and clearance of Electrical Inspector to the Government.
- Interface, including all documentation, coordination and necessary tests, for obtaining statutory approval and sanction of Commissioner Metro Rail Safety to the Government for opening the system for public carriage of passengers.

15.1.7 INTERFACE WITH POWER SUPPLY AUTHORITIES

KPTCL is the nodal agency for supplying the power. The RSS Contractor shall be required to interface with agencies like KPTCL, BESCOM, BWSSB, BBMP, NHAI, BDA and other relevant agencies.

Power Supply required for Traction and Auxiliary purposes will be obtained from KPTCL referred to as “Power Supply Authority (PSA)” and the RSS Contractor is required to interface with the PSA for the following items:

- Take-off points at PSA Substations
- Protection Co-ordination
- Metering Equipment
- Data exchange
- 220 kV/66 kV Cabling

The RSS Contractor is required to interface with the PSA. The interface requirements with PSA are listed in Table given below:

Item No.	Item Description	RSS Contractor	PSA
1	Take-off points at PSA substation	<ul style="list-style-type: none"> • Shall coordinate with PSA for construction of HT bays in PSA premises and to ensure that the necessary CBs and instrument transformers are provided for necessary protection and measurement. • Shall also provide cable terminations, cable paths, cable support structure inside PSA substation for BMRCL HT feeder cables. • Shall provide earthing arrangement for new bays at Grid Substation in coordination with PSA 	<ul style="list-style-type: none"> • PSA will indicate at site as well as schematically the arrangements for the outgoing feeders to BMRCL substations from PSA (KPTCL) Grid Substation. • PSA will accord permission to work.
2	Protection coordination	<ul style="list-style-type: none"> • Shall propose a protection scheme and obtain approval from PSA. • Shall provide and install protection relays such as differential protection, distance protection, over current protection at BMRCL RSS with the approval of PSA. • Shall propose protection relay settings to PSA ensuring proper relay co-ordination and obtain approvals. • If any pilot wire is required to be provided, for protection, the same shall be supplied by the RSS Contractor. • The pilot wire shall be armoured type. • Coordinate with PSA for installation of cable protection relays in PSA switchgears. 	<ul style="list-style-type: none"> • Shall verify and approve the final scheme of protection • Shall verify and approve relay settings • Shall provide and install the protection relays at KPTCL GSS. • Shall provide spare core of protection CT for 220kV/ 66kV cable protection relays.

Item No.	Item Description	RSS Contractor	PSA
3	Metering equipment	<ul style="list-style-type: none"> Shall prepare document which includes specifications and necessary arrangement required for Tariff metering equipment and submit to PSA for approval Shall provide the necessary check meters (Main & check meters) as per the requirements of PSA for measurement of voltage, current, PF, kVA, kWh, kVARh at BMRCL RSS. 	<ul style="list-style-type: none"> PSA will verify and approve the specifications and necessary arrangement required for metering equipment to measure kWh, kVARh, kVA, PF, current and voltage at BMRCL Substations.
4	Data exchange	<ul style="list-style-type: none"> Shall provide and obtain approval of a list of data/information to be exchanged with PSA through SCADA. Shall co-ordinate with PSA for exchange of data. For communication between PSA controller and BMRCL RSS Controller Permanent phones will be provided by Telecom Contractor 	<ul style="list-style-type: none"> PSA will approve the final list of data/ information identified for exchange through SCADA Supply and install RTU and terminate the SCADA/ LV Power cables in PSA installation for the equipment for which data has to be exchanged. Shall allow Contractor to install telephone at an appropriate location in PSA GSS.
5	Supply, laying, installation of 66kV/220kV Cables from PSA GSS to BMRCL RSS	<ul style="list-style-type: none"> Shall supply, lay and install cables Shall supply & install cable terminations at either end. Shall co-ordinate with PSA for path for laying cable inside PSA GSS. Shall co-ordinate with PSA for deciding the location of exiting cables from PSA GSS 	<ul style="list-style-type: none"> Shall provide necessary assistance for installation of cables and terminations Shall allow Contractor to lay cables in the existing path wherever possible.
6	Earthing	Shall propose an earthing arrangement in consultation with PSA Shall make necessary arrangement for earthing	Shall scrutinize and approve earthing arrangement
7	Cable path inside substation of PSA	Shall construct cable trench in coordination with PSA, as per approved design including covers for laying cables in case no spare trench or spare capacity is available in existing trench of PSA.	Shall permit laying of cables in existing trench or spare trench if available in the GSS. If no trench is available, PSA shall permit and approve construction and design of new trench for laying cables.

15.1.8 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 5.1.11 above](#) shall apply as relevant to the context.

CHAPTER 16

16.0 PSD/PSG SYSTEM INTERFACES

16.1.1 INTERFACES WITH ELEVATED CIVILCONTRACTORS

Refer to [Para 2.1.9 above](#)

16.1.2 INTERFACES WITH UG CIVILCONTRACTORS

Refer to [Para 3.1.9 above](#)

16.1.3 INTERFACES WITH DEPOT CIVILCONTRACTORS

Refer to [Para 4.1.10 above](#)

16.1.4 INTERFACES WITH ELEVATED E&M CONTRACTORS

Refer to [Para 5.1.6 above](#)

16.1.5 INTERFACES WITH UG E&M CONTRACTORS

Refer to [Para 6.1.6 above](#)

16.1.6 INTERFACES WITH DEPOT E&M CONTRACTORS

Refer to [Para 7.1.8 above](#)

16.1.7 INTERFACES WITH ELEVATED FINISHING WORKS CONTRACTORS

Refer to [Para 8.1.6 above](#)

16.1.8 INTERFACES WITH UG FINISHING WORKS CONTRACTORS

Refer to [Para 9.1.6 above](#)

16.1.9 INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS

Refer to [Para 10.1.7 above](#)

16.1.10 INTERFACES WITH S&TC CONTRACTOR

Refer to [Para 11.14 above](#)

16.1.11 INTERFACES WITH RS CONTRACTOR

Refer to [Para 12.1.10 above](#)

16.1.12 INTERFACE WITH TVS CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	PSD/PSG Contractor	TVS/ECS Contractor
1	Interface coordination	Shall get the details of pressure effects on PSD induced by train piston effect when train is entering in the station and design the PSD and its mounting arrangements accordingly.	Shall provide the details of pressure effects on PSD induced by train piston effect when train is entering into the station

16.1.13 INTERFACE WITH ECS CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	PSD/PSG Contractor	ECS Contractor
1	Heat load data	Shall provide the location, size and quantity of PSD motor as well as the heat generation load from PSD system to design ECS system	Shall get the location, size and quantity of PSD motor as well as the heat generation load from PSD system to design ECS system
2	Pressure effect	Shall get the details of pressure effects on PSD induced by train piston effect when train is entering in the station and design the PSD and its mounting arrangements accordingly	Shall provide the details of Pressure effects of PSD induced by train piston effect when train is entering the station
3	Door Sizes	Shall provide the details of PSD and fixed frame door sizes	Shall incorporate the details for arriving the Infiltration and Ex filtration heat losses
4	Design stage	Shall provide the details of train speed, acceleration, deceleration, dwell time and operating headways in each underground station to do PSD Infiltration and ex filtration simulation and to calculate heat load capacities in platforms	Shall get the details of train speed, acceleration, deceleration, dwell time and operating headways in each underground station to do PSD Infiltration and ex filtration simulation and to calculate heat load capacities in platforms

16.1.14 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 5.1.11 above](#) shall apply as relevant to the context

16.1.15 INTERFACE WITH PST CONTRACTORS

Refer to [Para 14.18 above](#)

16.1.16 INTERFACE WITH TELECOM SYSTEM CONTRACTOR

Refer to [Para 13.20 above](#)

CHAPTER 17

17.0 AFC SYSTEM INTERFACES

17.1.1 INTERFACES WITH ELEVATED CIVIL CONTRACTORS

Refer to [Para 2.1.10 above](#)

17.1.2 INTERFACES WITH UG CIVIL CONTRACTORS

Refer to [Para 3.1.10 above](#)

17.1.3 INTERFACES WITH DEPOT CIVIL CONTRACTORS

Refer to [Para 4.1.11 above](#)

17.1.4 INTERFACES WITH ELEVATED E&M CONTRACTORS

Refer to [Para 5.1.7 above](#)

17.1.5 INTERFACES WITH UG E&M CONTRACTORS

Refer to [Para 6.1.7 above](#)

17.1.6 INTERFACES WITH DEPOT E&M CONTRACTORS

Refer to [Para 7.1.9 above](#)

17.1.7 INTERFACES WITH ELEVATED FINISHING WORKS CONTRACTORS

Refer to [Para 8.1.7 above](#)

17.1.8 INTERFACES WITH UG FINISHING WORKS CONTRACTORS

Refer to [Para 9.1.7 above](#)

17.1.9 INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS

Refer to [Para 10.1.8 above](#)

17.1.10 INTERFACES WITH SIGNALLING & TRAIN CONTROL (S&TC) CONTRACTOR

Refer to [Para 11.15 above](#)

17.1.11 INTERFACES WITH TELECOM CONTRACTOR

Refer to [Para 13.1.14 above](#)

17.1.12 INTERFACE WITH ECS CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	AFC Contractor	ECS Contractor
	Design Stage		
1	Equipment heat load	Shall provide the details of equipment heat generation load, number of persons and Ventilation / Air conditioning requirements in the AFC system such as Ticket office, Excess fare office (EFO), and automatic ticket gates etc., to design Underground Station ECS system	Shall get the details of equipment heat generation load, number of persons and Ventilation / Air conditioning requirements in the AFC system such as Ticket office, Excess fare office (EFO), and automatic ticket gates etc., to design Underground Station ECS system.
	C&I Stage		
2	C&I stage	Shall coordinate	Shall install Ventilation and Air Conditioning (VAC) equipment in the AFC system such as Ticket office, Ticket office store (TOST), Secure suite, Excess fare office (EFO) and AFC.
	T&C Stage		
3	T&C stage	Shall attend and verify ECS parameters such as temperature and relative humidity in the AFC system	Shall conduct joint testing on the station VAC system
	O&M Stage		
4	ECS system O&M	Shall cooperate and support the O&M activities as relevant	Shall lead the O&M activities of the ECS system

17.1.13 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 5.1.11 above](#) shall apply as relevant to the context

CHAPTER 18

18.0 ELEVATOR (LIFT) INTERFACES

18.1.1 INTERFACES WITH ELEVATED CIVIL CONTRACTORS

Refer to [Para 2.1.11 above](#)

18.1.2 INTERFACES WITH UG CIVIL CONTRACTORS

Refer to [Para 3.1.11 above](#)

18.1.3 INTERFACES WITH DEPOT CIVIL CONTRACTORS

Refer to [Para 4.1.12 above](#)

18.1.4 INTERFACES WITH ELEVATED E&M CONTRACTORS

Refer to [Para 5.1.8 above](#)

18.1.5 INTERFACES WITH UG E&M CONTRACTORS

Refer to [Para 6.1.8 above](#)

18.1.6 INTERFACES WITH DEPOT E&M CONTRACTORS

Refer to [Para 7.1.10 above](#)

18.1.7 INTERFACES WITH ELEVATED FINISHING WORKS CONTRACTORS

Refer to [Para 8.1.8 above](#)

18.1.8 INTERFACES WITH UG FINISHING WORKS CONTRACTORS

Refer to [Para 9.1.8 above](#)

18.1.9 INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS

Refer to [Para 10.1.9 above](#)

18.1.10 INTERFACES WITH TELECOM CONTRACTOR

Refer to [Para 13.1.15 above](#)

18.1.11 INTERFACE WITH ECS CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Elevator (Lift) Contractor	ECS Contractor
	Design Stage		
1	Heat load of equipment	Provide heat loads of lifts and associated control panels	Design of ECS taking into consideration of heat loads from lifts
	C&I Stage		
2	ECS system installation	Shall coordinate as needed	Shall install the ECS system
	T&C Stage		
3	Nil		
	O&M Stage		
4	Nil		

18.1.12 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 5.1.11 above](#) shall apply as relevant to the context

CHAPTER 19

19.0 ESCALATORS INTERFACES

19.1.1 INTERFACES WITH ELEVATED CIVIL CONTRACTORS

Refer to [Para 2.1.12 above](#)

19.1.2 INTERFACES WITH UG CIVIL CONTRACTORS

Refer to [Para 3.1.12 above](#)

19.1.3 INTERFACES WITH DEPOT CIVIL CONTRACTORS

Refer to [Para 4.1.13 above](#)

19.1.4 INTERFACES WITH ELEVATED E&M CONTRACTORS

Refer to [Para 5.1.9 above](#)

19.1.5 INTERFACES WITH UG E&M CONTRACTORS

Refer to [Para 6.1.9 above](#)

19.1.6 INTERFACES WITH DEPOT E&M CONTRACTORS

Refer to [Para 7.1.11 above](#)

19.1.7 INTERFACES WITH ELEVATED FINISHING WORKS CONTRACTORS

Refer to [Para 8.1.9 above](#)

19.1.8 INTERFACES WITH UG FINISHING WORKS CONTRACTORS

Refer to [Para 9.1.9 above](#)

19.1.9 INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS

Refer to [Para 10.1.10 above](#)

19.1.10 INTERFACES WITH TELECOM CONTRACTOR

Refer to [Para 13.1.15 above](#)

19.1.11 INTERFACE WITH ECS CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	Escalator Contractor	ECS Contractor
	Design Stage		
1	Heat load of equipment	Provide heat loads of escalators and associated control panels	Design of ECS taking into consideration of heat loads from escalators
	C&I Stage		
2	ECS system installation	Shall coordinate as needed	Shall install the ECS system
	T&C Stage		
3	Nil		
	O&M Stage		
4	Nil		

19.1.12 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 5.1.11 above](#) shall apply as relevant to the context

CHAPTER 20

20.0 TRACK SYSTEM INTERFACES

20.1.1 INTERFACES WITH ELEVATED CIVIL CONTRACTORS

Refer to [Para 2.1.13 above](#)

20.1.2 INTERFACES WITH UG CIVIL CONTRACTORS

Refer to [Para 3.1.13 above](#)

20.1.3 INTERFACES WITH DEPOT CIVIL CONTRACTORS

Refer to [Para 4.1.14 above](#)

20.1.4 INTERFACES WITH SIGNALLING & TRAIN CONTROL (S&TC) CONTRACTOR

Refer to [Para 11.16 above](#)

20.1.5 INTERFACES WITH ROLLING STOCK CONTRACTOR

Refer to [Para 12.1.11 above](#)

20.1.6 INTERFACES WITH TELECOM CONTRACTOR

Refer to [Para 13.1.16 above](#)

20.1.7 INTERFACES WITH POWER SUPPLY & TRACTION (PST) CONTRACTOR

Refer to [Para 14.1.14 above](#)

20.1.8 INTERFACES WITH M&P CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item no.	Purpose / Subject of interface	Track work (TRW) Contractor	M&P Contractor (M&P)
	Design Stage		
1	Automatic Train Wash Plant	To provide details of track slab and carry out possible modifications as suggested by M&P contractor.	<ul style="list-style-type: none"> Provide plant GAD and other details, study the GFC drawings of track slab and suggest for any modification required. Co-ordinate with TRW Contractor for Track laying programs and track alignment. Connection of drainage to drain point.
2	CNC Under floor Wheel Lathe with Synchronized Shunting System	<ul style="list-style-type: none"> Laying and alignment of track as per shed layout Positioning / cutting of track to accommodate pit wheel lathe auxiliary rails 	<ul style="list-style-type: none"> Provide plant GAD and other details as required by TRW Contractor Co-ordinate with TRW Contractor for Track laying programs and track alignment.
3	Under floor train lifting system for 6-car unit	<ul style="list-style-type: none"> Laying and alignment of track as per shed layout Positioning / cutting of track to accommodate concrete rail bridge and its rails Demarcation and alignment of the track with rail installation 	<ul style="list-style-type: none"> Provide plant GAD and other details as required by TRW Contractor Co-ordinate with TRW Contractor for Track laying programs and track alignment.
4	Bogie Testing Machine	<ul style="list-style-type: none"> Laying and alignment of track as per shed layout Positioning / cutting of track to accommodate the machine's auxiliary rails 	Provide plant GAD and other details as required by TRW Contractor
5	Bogie turntables (1 set = 4 nos.)	<ul style="list-style-type: none"> Laying and alignment of track as per shed layout Positioning / cutting of track to accommodate the bogie turntables 	Provide plant GAD and other details as required by TRW Contractor
	C&I Stage		
6	All relevant items	Shall install the tracks as per agreed interfaces	Shall manufacture and install/commission the respective M&Ps as per agreed interfaces
	T&C Stage		
7	Testing & commissioning	Shall collaborate and associate for testing & commissioning of respective M&Ps as required	Shall lead the testing & commissioning of respective M&Ps and collaborate / associate with RS Contractor as required
	Maintenance Stage		
8	Nil		

20.1.9 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 5.1.11 above](#) shall apply as relevant to the context

CHAPTER 21

21.0 M&P CONTRACTORS' INTERFACES

21.1.1 INTERFACES WITH DEPOT CIVIL CONTRACTORS

Refer to [Para 4.1.15 above](#)

21.1.2 INTERFACES WITH DEPOT E&M CONTRACTORS

Refer to [Para 7.1.12 above](#)

21.1.3 INTERFACES WITH DEPOT FINISHING WORKS CONTRACTORS

Refer to [Para 10.1.11 above](#)

21.1.4 INTERFACES WITH ROLLING STOCK CONTRACTOR

Refer to [Para 0 above](#)

21.1.5 INTERFACES WITH POWER SUPPLY & TRACTION (PST) CONTRACTORS

Refer to [Para 14.1.15 above](#)

21.1.6 INTERFACES WITH TRACK WORK (TRW) CONTRACTOR

Refer to [Para 20.1.8 above](#)

21.1.7 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 5.1.11 above](#) shall apply as relevant to the context

21.1.8 INTERFACE WITH SIGNALLING & TRAIN CONTROL (S&TC) CONTRACTORS

Refer to [Para 11.20 above.](#)

CHAPTER 22

22.0 TVS CONTRACTOR'S INTERFACES

22.1.1 INTERFACES WITH UG CIVIL CONTRACTORS

Refer to [Para 3.1.14 above](#)

22.1.2 INTERFACES WITH UG E&M CONTRACTORS

Refer to [Para 6.1.10 above](#)

22.1.3 INTERFACES WITH UG FINISHING WORKS CONTRACTORS

Refer to [Para 9.1.10 above](#)

22.1.4 INTERFACES WITH SIGNALLING & TRAIN CONTROL (S&TC) CONTRACTORS

Refer to [Para 11.17 above](#)

22.1.5 INTERFACES WITH ROLLING STOCK CONTRACTORS

Refer to [Para 12.1.13 above](#)

22.1.6 INTERFACES WITH TELECOM CONTRACTORS

Refer to [Para 13.1.17 above](#)

22.1.7 INTERFACES WITH POWER SUPPLY & TRACTION (PST) CONTRACTORS

Refer to [Para 14.1.16 above](#)

22.1.8 INTERFACES WITH PSD/PSG CONTRACTORS

Refer to [Para 16.1.12 above](#)

22.1.9 INTERFACES WITH ESCALATOR CONTRACTOR

Refer to [Para 19.1.11 above](#)

22.10 INTERFACE WITH ECS CONTRACTOR

The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

Item No.	Subject	TVS Contractor	ECS Contractor
	Design Stage		
1	ECS and TVS Equipment heat load	Provide equipment heat load (TVS and TES equipment) Verify the design provided by the ECS Contractor	Shall incorporate in ECS design
2	Control and monitoring	TVS-SCADA provision in OCC and monitoring and control of ECS and E&M SCADA I/O points in OCC	Provide the ECS and E&M SCADA I/O point lists to be controlled and monitored in OCC
3	ECS shaft flow rate	Shall provide the flow rates and area required in the ECS shaft of the TES to design ECS shaft	Shall get the flow rates and area required in the ECS shaft of the TES to design ECS shaft
4	Cooling dumping	Shall provide the additional tunnel heat load details during normal mode to achieve tunnel temperatures based on the SES/ CFD simulation results	Shall accommodate additional tunnel heat and provide ducting arrangement through AHU cooling coil.
5	System operating modes	Shall get the details as provided by ECS Contractor to know in which mode the ECS system is operating for the safety aspects and to allot input and output provision in the TVS SCADA	Shall provide dedicated inputs to TVS SCADA to indicate in which mode the ECS system is operating for the safety aspects
6	System operation control	Shall provide dedicated inputs to ECSSCADA to indicate in which mode the TVS system is operating for the safety aspects and to request activate chiller for the TVS if required in the future	Shall get the details as provided by TVS Contractor to know in which mode the TVS is operating for the safety aspects and to allot input and output provision in the ECSSCADA to activate chiller for the TVS if required in the future
7	System interface design	At Station, shall design the suitable interface device for communicating with ECSSCADA system in a compatible manner in respect of hardware, message format and protocol. Shall advise the details of status or mode of operation and high-level alarms to be exchanged between Tunnel Ventilation System and ECSSCADA System	At SCR, shall design the suitable interface device at ECSSCADA end in a compatible manner in respect of hardware, message format and protocol for displaying / monitoring the status or mode of operation and high-level alarms of the TVS
	C&I Stage		
8	Equipment installation	Control cable from BMS RTU (By ECS Contractor) to TVS SCADA	ECS Contractor will be fully responsible for the final certification of the installation of the BMS installation BMS cable from BMS to RTU (including RTU)
	T&C Stage		

Item No.	Subject	TVS Contractor	ECS Contractor
9	System testing	TVS Contractor will be responsible for the integration testing of the ECS system from OCC	ECS Contractor will be responsible for the integration testing of the ECS system and station BMS
	O&M Stage		
10	Nil		

22.10.1 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 5.1.11 above](#) shall apply as relevant to the context

CHAPTER 23

23.0 ECS CONTRACTOR'S INTERFACES

23.1.1 INTERFACES WITH UG CIVIL CONTRACTORS

Refer to [Para 3.1.15 above](#)

23.1.2 INTERFACES WITH UG E&M CONTRACTORS

Refer to [Para 0 above](#)

23.1.3 INTERFACES WITH UG FINISHING WORKS CONTRACTORS

Refer to [Para 9.1.11 above](#)

23.1.4 INTERFACES WITH SIGNALLING & TRAIN CONTROL (S&TC) CONTRACTORS

Refer to [Para 0 above](#)

23.1.5 INTERFACES WITH ROLLING STOCK CONTRACTORS

Refer to [Para 12.1.14 above](#)

23.1.6 INTERFACES WITH TELECOM CONTRACTORS

Refer to [Para 13.1.18 above](#)

23.1.7 INTERFACES WITH POWER SUPPLY & TRACTION (PST) CONTRACTORS

Refer to [Para 14.1.17 above](#)

23.1.8 INTERFACES WITH PSD/PSG CONTRACTORS

Refer to [Para 16.1.13 above](#)

23.1.9 INTERFACES WITH AFC CONTRACTORS

Refer to [Para 17.1.12 above](#)

23.1.10 INTERFACES WITH LIFT CONTRACTORS

Refer to [Para 18.1.11 above](#)

23.1.11 INTERFACES WITH ESCALATOR CONTRACTOR

Refer to [Para 19.1.11 above](#)

23.1.12 INTERFACES WITH TVS CONTRACTORS

Refer to [Para 22.10 above](#)

23.1.13 INTERFACE WITH IT/AMS (ASSET MANAGEMENT SYSTEM) CONTRACTOR

The provisions of [Para 5.1.11 above](#) shall apply as relevant to the context

23.1.14 INTERFACE WITH SES CONSULTANT

Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

SN	Subject	ECS Contractor	SES Consultant
1	Detailed design of ECS and equipment sizing calculations	<ul style="list-style-type: none">• Taking actual site conditions, routings & size of ductworks and pipe works, carry out the pressure drop/head calculations for fans and pumps in deciding equipment capacity and head for equipment selection/procurement.• Verify the major equipment sizing	<ul style="list-style-type: none">• Carry out the SES and CFD computer simulations• Provide Operation mode tables• Provide equipment sizing of major ECS equipment (Chiller, Cooling towers, pumps, AHUs)
2	Installation of ECS System	Will be responsible for the supply, delivery, installation, testing and commissioning of the complete ECS system	Shall provide design related clarifications during installation as needed

CHAPTER 24

24.0 IT/AMS CONTRACTOR'S INTERFACES

24.1.1 INTERFACES WITH ELEVATED CIVIL CONTRACTORS

Refer to [Para 2.1.14 above](#)

24.1.2 INTERFACES WITH UG CIVIL CONTRACTORS

Refer to [Para 3.1.16 above](#)

24.1.3 INTERFACES WITH DEPOT CIVIL CONTRACTORS

Refer to [Para 4.1.16 above](#)

24.1.4 INTERFACES WITH ELEVATED E&M CONTRACTORS

Refer to [Para 5.1.11 above](#)

24.1.5 INTERFACES WITH UG E&M CONTRACTORS

Refer to [Para 6.1.12 above](#)

24.1.6 INTERFACES WITH DEPOT E&M CONTRACTORS

Refer to [Para 7.1.13 above](#)

24.1.7 INTERFACES WITH ELEVATED FINISHING CONTRACTORS

Refer to [Para 8.1.10 above](#)

24.1.8 INTERFACES WITH UG FINISHING

Refer to [Para 9.1.12 above](#)

24.1.9 INTERFACES WITH DEPOT FINISHING CONTRACTORS

Refer to [Para 10.1.12 above](#)

24.1.10 INTERFACES WITH S&T CONTRACTORS

Refer to [Para 11.19 above](#)

24.1.11 INTERFACES WITH ROLLING STOCK CONTRACTORS

Refer to [Para 12.1.15 above](#)

24.1.12 INTERFACES WITH TELECOM CONTRACTORS

Refer to [Para 13.1.19 above](#)

24.1.13 INTERFACES WITH PST CONTRACTORS

Refer to [Para 14.1.18 above](#)

24.1.14 INTERFACES WITH RSS CONTRACTORS

Refer to [Para 15.1.8 above](#)

24.1.15 INTERFACES WITH PSDCONTRACTORS

Refer to [Para 16.1.14 above](#)

24.1.16 INTERFACES WITH AFC CONTRACTORS

Refer to [Para 17.1.13 above](#)

24.1.17 INTERFACES WITH LIFTCONTRACTORS

Refer to [Para 18.1.12 above](#)

24.1.18 INTERFACES WITH ESCALATOR CONTRACTOR

Refer to [Para 19.1.12 above](#)

24.1.19 INTERFACES WITH TRACK CONTRACTOR

Refer to [Para 20.1.9 above](#)

24.1.20 INTERFACES WITH M&P CONTRACTOR

Refer to [Para 21.1.7 above](#)

24.1.21 INTERFACE WITH TVS CONTRACTOR

Refer to [Para 22.10.1 above](#)

24.1.22 INTERFACE WITH ECS CONTRACTOR

Refer to [Para 23.1.13 above](#)