8.1.2 Vibrators

8.1.2.1 Concrete shall be compacted with mechanical vibrating equipment supplemented, if necessary to obtain consolidation, by hand spreading, rodding and tamping. The vibrators shall be of immersion type with operational frequency ranging between 8,000 to 12,000 vibrations per minute. All vibrators shall comply with IS 2505. Screed board concrete vibrators or concreting vibrating tables or form vibrators conforming to IS 2506, 2514 and 4656 respectively shall be used where specifically required and directed by Engineer-in-Charge.

8.1.2.2 Immersion type vibrators shall be inserted in a vertical position at intervals of about 600 mm, depending upon the mix, the equipment used, and experience on work. The vibrators shall be withdrawn slowly. The spacing shall provide some overlapping of the area vibrated at each insertion. In no case shall vibrators be used to transport concrete inside the forms. Over vibration or under vibration shall not be permitted as both are harmful. Hand tamping in some cases may be allowed subject to the approval of the Engineer-in-Charge.

8.1.2.3 In placing concrete in layers which are advancing horizontally as the work progresses, great care shall be exercised to ensure adequate vibration, bonding and moulding of the concrete between the succeeding batches.

8.1.2.4 The vibrator shall penetrate the layer being placed and also penetrate the layer below while the under layer is still plastic to ensure good bond and homogeneity between the two layers and prevent the formation of cold joints.

8.1.2.5 Care shall be taken to prevent contact of vibrators against all embedded reinforcing steel or inserts. Vibrators shall not be allowed to come in contact with forms.

8.1.2.6 The use of form vibrators shall not be permitted for compaction of in-situ concrete without specific authorization of the Engineer-in-Charge.

8.1.2.7 The use of surface vibrators of screed board type shall not be permitted for consolidation of concrete under ordinary conditions. However, for thin slabs (of thickness less than 200 mm) surface vibration by such vibrators may be permitted, upon approval of the Engineer-in-Charge.

8.1.2.8 Whenever vibration has to be applied externally, the design of formwork and the disposition of vibrators shall be carefully planned to ensure efficient compaction and to avoid surface blemishes.

8.2 Transportation

8.2.1 All concrete shall be conveyed from the mixer to the place of final deposit such as formwork as rapidly as possible using suitable buckets, dumpers, pumps, transit mixers containers or conveyors which shall be mortar leak tight. Care shall be taken to prevent the segregation or loss of the ingredients and maintaining the required workability. For structural concrete produced from Ready Mixed Concrete/ Batching Plants, concrete shall be transported from the plants to the sites only by transit mixers and Delivery Ticket for each delivery of concrete shall be maintained by the contractor.

8.2.2 During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted. All equipment used for transporting and placing of concrete shall be maintained in clean condition. All buckets, hoppers, chutes, dumpers and other equipment shall be thoroughly cleaned after each use.

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8.3 Placing and Compaction

8.3.1 Before placing concrete, all soil surfaces upon which or against which concrete is to be placed shall be well compacted and free from standing water, mud or debris. Soft or yielding soil shall be removed and replaced, with lean concrete or with selected soils/sand and compacted to the density as directed by Engineer-in-Charge. The surface of absorptive soil (against which concrete is to be placed) shall be moistened thoroughly so that moisture is not drawn from the freshly placed concrete. Similarly, for concrete to be placed on formworks, all chippings, shavings and sawdust etc. shall be removed from the interior of the forms before the concrete is placed.

8.3.2 Concrete shall not be placed until the formwork, the placement of reinforcing steel, embedded parts; pockets etc. have been inspected and approved by the Engineer- in-Charge. Any accumulated water on the surface of the bedding layer shall be removed by suitable means before start of placement. No concrete shall be placed on a water covered surface.

8.3.3 Concrete shall be discharged by vertical drop only and the drop height shall not normally exceed 1.5 metre throughout all stages of delivery until the concrete comes to rest in forms. However, drop height can be relaxed by the Engineer-in-Charge as per the provisions given under Cl. 8.1.1. For continuous concreting operation windows of suitable size shall be kept in the formwork or chutes shall be used to avoid segregation of concrete.

8.3.4 Concrete shall be deposited as near as practicable in its final position to avoid rehandling. Concrete shall be placed in successive horizontal layers. The bucket loads, or other units of deposit, shall be placed progressively along the face of the layer with such over-lap as will facilitate spreading the layer of uniform depth and texture with a minimum of hand shoveling. Any tendency to segregation shall be corrected by shovelling coarse aggregates into mortar rather than mortar on the coarse aggregates. Such a tendency for segregation shall be corrected by redesign of mix, change in process or other means, as directed by the Engineer-in-Charge.

8.3.5 All struts, stays and braces (serving temporarily to hold the forms in correct shape and alignment pending the placing of concrete at their locations) shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These shall not be buried in the concrete. Concrete shall be thoroughly compacted with vibrators and fully worked around the reinforcement, embedded fixtures and into corners of formwork before setting commences and shall not be subsequently disturbed. Methods of placing shall be such as to preclude segregation and avoid displacement of reinforcement or formwork. The formation of stone-pockets or mortar bondage in corners and against face forms shall not be permitted. Should these occur, they shall be dug out, reformed and refilled to sufficient depth and shape for thorough bonding as directed by the Engineer-in-Charge. Care shall be taken to avoid displacement of reinforcement and embedded inserts or movement of formwork.

8.3.6 Unless otherwise approved, concrete shall be placed in single operation to the full thickness of foundation rafts, slabs, beams and similar members. Concrete shall be placed continuously until completion of the part of the work between approved construction joints or as directed by the Engineer-in-Charge.

8.3.7 The method of placing and compaction employed in any particular section of the work shall be to the entire satisfaction of the Engineer-in-Charge.

8.3.8 During hot weather (atmospheric temperature above 40 degree Celsius) or cold weather (atmospheric temperature below 5 degree Celsius, the concreting shall be done as per the procedure set out in IS 7861).

8.3.9 Concrete that has set standing and becomes stiffened shall not be used in the work.

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8.3.10 Continuous Concreting

Where called out on the drawings, continuous concreting shall be done in a single operation as per the requirements of IS 456 and IS 2974. Sufficient "Windows" shall be left in the formwork for pouring & compaction of concrete and inspection. These windows shall be fixed tight once the level of concrete reaches their levels.

8.3.11 Concreting under special conditions

a) Work in extreme weather conditions during hot or cold weather, the concreting shall be done as per procedure set out in IS 7861(Part 1) or IS 7861 (Part2).

b) Under water concreting shall be as per clause 14.2 of IS 456.

8.4 Items Embedded in Concrete

8.4.1 Concreting shall not be started unless the electrical conduits, pipes, fixtures etc., wherever required, are laid by the concerned agency. The Contractor shall afford all the facilities and maintain co-ordination of work with other agencies engaged in electrical and such other works as directed by the Engineer-in-Charge.

8.4.2 Before concreting, the Contractor shall provide, fabricate and lay in proper position all metal inserts, anchor bolts, pipes etc. (which are required to be embedded in concrete members) as per relevant drawings and directions of Engineer-In-Charge.

8.4.3 All embedment, inserts etc. shall be fully held and secured in their respective positions by the concerned agencies to the entire satisfaction of Engineer-in-Charge so as to avoid any dislocation or displacement during the concreting operations. The Contractor shall take all possible care during concreting to maintain these embedment/inserts in their exact locations.

9.0 CONSTRUCTION JOINTS

9.1 Construction joints shall be provided in position as shown or described on the drawings or as directed by the Engineer-in-Charge. Such joints shall be kept to the minimum. These shall be straight and at right angles to the direction of main reinforcement and shall be placed at accessible locations to permit cleaning out of laitance, cement slurry and unsound concrete.

9.2 In a column, the joint shall be formed about 100 mm to 150 mm below the lowest soffit of the beams framing into it. Concrete in a beam and slab shall be placed throughout without a joint but if the provision of a joint is unavoidable, the joint shall be vertical and located within 1/3 to 1/4 of the span, unless otherwise shown on the drawings.

9.3 When stopping the concrete on a vertical plane in slabs and beams, an approved stop board shall be placed with necessary slots for reinforcement bars. The construction joints shall be keyed by providing a triangular or trapezoidal fillet nailed on the stop board. Inclined joints shall not be permitted. Any concrete flowing through the joints of stop board shall be removed soon after the initial set. When concrete is stopped on a horizontal plane, the surface shall be roughened and cleaned after the initial set and a triangular or trapezoidal groove shall be provided for keying with the new concrete later.

9.4 When the work has to be resumed on a surface which has hardened, such surface shall be cleared of any foreign materials and roughened to expose the tips of the coarse aggregate. This may be done by manual chipping of concrete, with a high pressure water jet or by any other appropriate means as per Engineer-in-Charge's directions. It shall then be swept clean and thoroughly washed and wetted before any new concrete is poured. Any set mortar or concrete sticking to the exposed reinforcing rods in and around such joints shall be thoroughly removed. The reinforcements shall be wire brushed and washed just before

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pouring any cement slurry or mortar. For vertical joints neat cement slurry shall be applied on the surface before it is dry. For horizontal joints the surface shall be covered with a layer of mortar about 10 to 15 mm thick composed of cement and sand in the same ratio as the cement and sand in concrete mix. This layer of cement slurry or mortar shall be freshly mixed and applied immediately before placing new concrete.

9.5 Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brushes, care being taken to avoid dislodgement of particles of aggregate. The surface shall be thoroughly wetted and all free water removed. The surface shall then be coated with neat cement slurry. On this surface layer of concrete not exceeding 150 mm in thickness shall first be placed and shall be well rammed against old work, particular attention being paid to corners and close spots; work thereafter shall proceed in normal way.

10.0 SEPARATION JOINT

10.1 Separation joint shall be obtained by using an approved Alkathene sheet stuck on the surface against which concrete shall be placed. Adequate care shall be taken to cause no damage to the sheet.

11.0 EXPANSION JOINTS/ISOLATION JOINT

11.1 Expansion/ Isolation joints in structures shall be formed in the positions and to the shapes shown in the relevant drawings. Joints shall be filled with joint filling material as stipulated in the drawings/schedule of rates. Isolation joints shall be provided around all equipment foundations, columns, pedestals, trenches etc. on grade.

12.0 WATER STOPS

PVC water stops as per EIL Specification No. 6-68-0002 for materials shall be accurately cut, fitted and integrally joined as per manufacturer's specifications to provide a continuous, watertight diaphragm at all points.

The water stops shall be located and embedded at expansion/contraction/ construction joints as indicated in the drawings or directed by the Engineer-in-Charge.

Adequate provision shall be made for the support and protection of water stops during the progress of the work. Damaged water stops shall be replaced and/or repaired as directed.

13.0 PROTECTION OF FRESHLY LAID CONCRETE

13.1 Newly placed concrete shall be protected, by approved means, from rain, sun and wind. Concrete placed below the ground level shall be protected from falling earth during and after placing. Surface shall be kept free from contact with such ground or with water draining from such ground during placing of concrete for a period of at least 3 days, unless otherwise directed by the Engineer-in-Charge. The ground water around newly poured concrete shall be kept to an approved level by pumping or other approved means of drainage and adequate steps shall be taken to prevent floatation and flooding. Steps shall be taken to protect immature concrete from damage by debris, loading, vibration, abrasion, mixing with deleterious materials that may, in the opinion of the Engineer-in-Charge, impair the strength and/or durability of the concrete.

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14.0 CURING

14.1 Concrete shall be cured by keeping it continuously moist wet for the specified period of time to ensure complete hydration of cement and its hardening. Curing shall be started after 8 hours of placement of concrete in normal weather, and in hot weather after 4 hours. The water used for curing shall be of the same quality as that used for making of concrete.

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliances such as hose, sprinklers etc. A layer of sacking, canvas, hessian, or other approved material, which will hold moisture for long periods and prevent loss of moisture from the concrete, shall be used as covering. Type of covering which would stain, disfigure or damage the concrete, during and after the curing period, shall not be used. Only approved covering shall be used for curing.

Exposed surfaces of concrete shall be maintained continuously in a damp or wet condition for at least the first 7 days after placing of concrete.

The Contractor shall have all equipment and materials required for curing on hand and ready to use before concrete is placed.

For curing the concrete in pavements, floors, flat roofs or other level surfaces, the ponding method of curing shall be used. For the first 24 hours after concreting, the concrete shall be cured by use of wet sacking, canvas, hessian etc. The minimum water depth of 25 mm for ponding shall be maintained. The method of containing the ponded water shall be approved by the Engineer-in-Charge. The ponded areas shall be kept continuously filled with water, and leaks, if any, shall be promptly repaired. Areas cured by ponding method shall be cleared of all debris and foreign materials after curing period is over.

Alternatively, membrane curing may be used in lieu of moist curing with the permission of the Engineer-in-Charge. Such compounds shall be applied to all exposed surfaces of the concrete by spraying or brushing as soon as possible after the concrete has set. Minimum film thickness of such curing compounds shall be as per the recommendation of the manufacturer so as to obtain an efficiency of 90% as specified by BS-8110. This film of curing compound shall be fully removed from the concrete surface after the curing period specified earlier. Engineer-in-Charge may not allow curing by curing compounds for those surfaces where use of curing compound may be detrimental to application of future finishes over the concrete. Impermeable membranes such as polyethylene sheeting closely covering the concrete surface may also be used.

14.2 For concretes containing Portland pozzolana cement or Portland slag cement, the curing period as given in Cl. 14.1 shall be doubled. Curing by ponding shall, however, commence after the first 24 hours of concreting.

15.0 FIELD TESTS

15.1 Materials Testing

15.1.1 Aggregates

Grading test on fine and coarse aggregates shall be carried out as per IS 2386 at intervals specified by the Engineer-in-Charge.

The mandatory tests and their frequencies shall be done as given in Table-3A & 3B below:

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Page 2562 of 4391 : B957-TENDER_DOC-B957-300-16-43-MR-T-3001 : Rev. A

TABLE – 3A
(For Concrete prepared at site by using Mechanical mixers)

MANDATORY TESTS ON SAND & STONE AGGREGATES

S. No	MATERIAL	TEST	FIELD / LAB TEST	MIN. QTY OF MATERIAL/ WORK FOR CARRYING OUT TEST	FREQUENCY OF TESTING*
1.	Sand	(a) Bulking of sand	Field Test	20 m^3	Every 20 m^3 or part thereof or more frequently as decided by the Engineer-in-Charge
		(b) Silt content	Field Test	20 m^3	
		(c) Particle size distribution	Field or Lab as decided by the Engineer-in-Charge	40 m^3	1) Every 40 m^3 of fine aggregate/sand required in RCC works only 2) Every 80 m^3 of fine aggregate/ sand required for other items
2.	Stone aggregate	a) Percentage of soft or deleterious materials	General visual inspection, laboratory test where required by Engineer -in-Charge or as specified	As required by Engineer-in-Charge	For all quantities
		b) Particle size distribution	Field or lab. as required by Engineer-in-Charge	45 m^3	For every 45 m^3 or part thereof as decided by Engineer-in-Charge
		c)Ten percent Fine value	Laboratory	45 m^3	Initial test and subsequent test as & when required by Engineer-in-Charge

* Fresh testing is mandatory whenever there is change in Source of materials.

TABLE – 3B
(Refer Cl. 4.4 & 4.6.1 of IS 4926)

(For Ready Mixed Concrete supplied by Ready Mixed Concrete Plants or from on/off-site Batching Plants)

MATERIALS TESTING REQUIREMENTS

S. No	AGGREGATE PROPERTY/ PARAMETER	TYPE OF AGGREGATE	ASSESSMENT OF TYPICAL PROPERTIES AND HIGH TEST RATE*	NORMAL MONITORING AND LOW TEST RATE*	REQUIREMENT FOR NORMAL MONITORING AND LOW TEST RATE
1.	**Grading**	Sand/Fine	Weekly	Monthly	Last 8 results conform to IS 383 or representative values
		Coarse-Single sized/ Graded	Weekly	Monthly	
2.	**Particle density** -Oven Dry -Saturated Surface Dry -Apparent	All Types	Weekly	3 Monthly	Last 4 results ±0.04 percent
3.	**Absorption**	All Types	Weekly	3 Monthly	Last 4 results ±0.04 percent

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S. No	AGGREGATE PROPERTY/ PARAMETER	TYPE OF AGGREGATE	ASSESSMENT OF TYPICAL PROPERTIES AND HIGH TEST RATE*	NORMAL MONITORING AND LOW TEST RATE*	REQUIREMENT FOR NORMAL MONITORING AND LOW TEST RATE
4.	**Bulk Density** - Loose - Compacted	All Types	Monthly	6 Monthly	Last 4 results ± 75kg/m³
5.	**Fines(Silt) Content**	Sand	Weekly	Monthly	Last 10 results <75 percent maximum allowed
		Coarse	Monthly	3 Monthly	
6.	**Aggregate Impact Value**	Coarse	As specified	As specified	-
7.	**10 % Fines**	Coarse	Yearly	Yearly	-
8.	**Flakiness**	Coarse	2 Weekly	6 Monthly	Last 3 results conform to standard
9.	**Chloride Content**	All Types	Weekly	6 Monthly	Last 3 results < 0.01 percent
10.	**Aggregate Abrasion Value** (Los Angeles Method)	Coarse	-	Yearly/ Source Change	-
11.	**Soundness**	Fine and Coarse	-	Yearly/ Source Change	-
12.	**Potential Alkali Aggregate Reactivity Including Petrography**	Fine and Coarse	-	5 Yearly/ Source Change	-
13.	**Petrographic Description** (General)	All Types	-	5 Yearly	-

***Note** : The high or low test rates apply in accordance with the following conditions:

a) High test rate
   i) To establish the typical characteristics of an aggregate, and
   ii) When significant changes in properties occur outside the tolerances for low test rates given.

b) Low test rate
   i) When the typical characteristics of the aggregate have been established, and
   ii) When subsequent tests lie within the tolerances for low test rates given

15.1.2 Water

The minimum testing frequencies shall be as follows:

SOURCE	PARAMETERS	FREQUENCY	REQUIEMENT
Non mains water (Untreated water extracted from wells, ponds, lakes, rivers, underground, etc.)	p^H value, Chloride ion content, Sulphate content and any other parameter in accordance with IS 456	Initially every week for first 6 weeks (average of test results to be taken) and then at 3-monthly interval	Need further investigation in case significant deviation observed in test results of 3-monthly interval samples from the original 6 weeks average
Mains water (Treated water supplied through piped network)	Same as above	Annual basis once all tests for source are satisfactory	In case Chloride content > 0.01%, testing frequency shall be reduced to 3 months

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15.2 Compaction Factor Test /Slump Test of Concrete

15.2.1 For structural quality concrete (excluding pavements, flooring etc.) at least one Slump Test shall be made for every compressive strength test carried out. More frequent tests shall be made if there is a distinct change in working conditions or if required by the Engineer-in-Charge.

In case of Ready Mixed Concrete, provisions of IS 4926 shall be followed.

15.2.2 For structural quality concrete for pavements & floorings, measurement of workability shall be by determination of compacting factor. Value of compacting factor of 0.75 to 0.8 shall generally be acceptable.

15.3 Strength Test of Concrete

15.3.1 Samples from fresh concrete shall be taken as per IS 1199 and cubes shall be made, cured and tested at 28 days in accordance with IS 516.

15.3.2 In order to get a relatively quicker idea of the quality of concrete, optional tests on beams for modulus of rupture at 72±2 hours or at 7 days, or compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength tests. For this purpose, the values shall be arrived at based on actual testing. In all cases, the 28 days compressive strength specified in Table-1 shall alone be the criterion for acceptance or rejection of the concrete in accordance with clause 15.3.9.

15.3.3 Sampling Procedure

A random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested that is, the sampling should be spread over the entire period of concreting and cover all mixing units.

15.3.4 Frequency of Sampling

The minimum frequency of sampling of concrete for each grade shall be in accordance with Table-4.

TABLE – 4
(Refer Cl. 15.2.2 of IS 456)

FREQUENCY OF CONCRETE SAMPLING

Quantity of concrete in the work (m^3)	Number of samples
1-5	1
6-15	2
16-30	3
31-50	4
51 & above	4 plus one additional sample for each additional 50m^3 or part thereof.

At least one sample shall be taken from each shift.

When concrete is produced at continuous production units such as ready mixed concrete/ batching plants, atleast one sample shall be taken for every 50m^3 of concrete or after every 50 batches, whichever occurs at a greater frequency or as decided by the Engineer-in-Charge. Samples shall be avoided from the first and the last cubic metre of concrete mix in a lot.

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15.3.5 Test Specimen

Three test specimens shall be made for each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 7 days or at the time of striking the formwork or to check the testing error. Additional samples may also be required for testing samples cured by accelerated methods as described in IS 9013. The specimen shall be tested as described in IS 516.

15.3.6 Identification mark on concrete test cubes:

The following numbering system shall be adopted on each 150 mm cube:

First line: ZZ	(Alpha code assigned by the Engineer -in-Charge to the Contractor for a particular contract starting with AA and progressing to AB, AC and so on).
Second line: XXXX	(Unique integer in ascending order starting from 1).
Third line: DD-MM-YY	(Date of casting of cube)

15.3.7 Test Results of Sample

The test results of the sample shall be the average of the strength of three specimens. The individual variation should not be more than $\pm$ 15 percent of the average. If more, the test results of the sample shall be considered invalid.

15.3.8 Standard Deviation

Standard deviation for each grade of concrete shall be calculated separately.

Standard deviation based on test results of samples:

a) The total number of test samples required to constitute an acceptable record for calculation of standard deviation shall be not less than 30. Attempts shall be made to obtain the 30 samples, as early as possible, when a mix is used for the first time.

b) For design of mix in the first instance, the value of standard deviation given in Table 8 of IS 456, Amendment No. 4 may be assumed.

c) As soon as sufficient results of samples are available, actual calculated standard deviation shall be used and the mix design shall be revised/ updated. However, when adequate past records for a similar grade exist and justify to the designer a value of standard deviation different from that shown in Table 8 of IS 456, Amendment No. 4, it shall be permissible to use that value.

d) For additional requirement on standard deviation refer clause 9.2.4 of IS 456.

15.3.9 Acceptance Criteria

15.3.9.1 Compressive Strength

The concrete shall be deemed to comply with the strength requirement when both the conditions as given in col. 2 & col.3 of Table-5 for that particular grade of concrete are simultaneously met. For working out standard deviation compressive test result of date wise serially logged 30 sample test result shall be used.

15.3.9.2 Flexural Strength

The concrete shall be deemed to comply with flexural strength requirements when both the following conditions are simultaneously met:

a) The mean strength determined from any group of four non-overlapping consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm^2.

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(For non overlapping consecutive compressive test result any one alternate set of four samples shall be used for verification of compliance to clause no. 16.1.a of IS 456)

b) The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm^2

Table-5
(Refer Cl. 16.1 & 16.3 of IS 456)

Characteristic Compressive Strength Compliance Requirement

Specified Grade	Mean of the Group of 4 Non-Overlapping Consecutive Test Results in N/mm^2	Individual Test Results in N/mm^2
M15 or above	$\geq f_{ck}$ + 0.825 x established standard deviation (rounded off to nearest 0.5N/mm^2) or $\geq f_{ck}$ + 3 N/mm^2, Whichever is greater	$\geq f_{ck}$ – 3 N/mm^2

NOTE : 1) In the absence of established value of standard deviation, the values given in Table 8 of IS 456, Amendment No. 4, may be assumed, and attempt should be made to obtain results of 30 samples as early as possible to establish the value of standard deviation.

2) For concrete of quantity 30 m^3 (where the number of samples to be taken is less than four as per the frequency of sampling given in cl. 15.3.4, Table 4), the mean of test results of all such samples shall be f_{ck} + 4 N/mm^2, minimum and the requirement of individual test results shall be f_{ck} – 2 N/mm^2, minimum. However, when the number of sample is only one as per Table 4, the requirement shall be f_{ck} + 4 N/mm^2.

15.3.9.3 Quantity of Concrete Represented by Strength Test Results

The quantity of concrete represented by group of four consecutive test results shall include the batches from which first and last samples were taken together with all intervening batches. Acceptance of concrete shall be applicable for serially logged 30 samples. In case serially logged samples are less than 30 then standard deviation of adjoining previous sample sets will be used for establishing acceptance criteria as per clause 16.1.a of IS 456.

For the individual test result requirements given in col. 3 of Table-5 or in item (b) of 15.3.9.2, only the particular batch from which the sample was taken shall be at risk.

Where the mean rate of sampling is not specified, the maximum quantity of concrete that four consecutive test results represent shall be limited to 60m^3.

15.3.9.4 If the concrete is deemed not to comply pursuant to Cl. 15.3.9.1 or 15.3.9.2, the structural adequacy of the parts affected shall be investigated and any consequential action as needed shall be taken (Refer Cl. 16.0).

15.3.9.5 Concrete of each grade shall be assessed separately.

15.3.9.6 Concrete is liable to be rejected if it is porous or honey-combed, its placing has been interrupted without providing a proper construction joint, the reinforcement has been displaced beyond the tolerances specified, or construction tolerances have not been met. However, the hardened concrete may be accepted after carrying out suitable remedial measures and tests to the fullest satisfaction of the Engineer-in-Charge.

15.3.9.7 Tolerance in leveling of concrete surface at foundation/ pedestal top level where grouting is to be done:

Maximum Plan Dimension	≤ 2m	>2m but ≤4m	> 4m
Tolerance in leveling	+ 10 mm	+ 10 mm	+ 10 mm
	- 10 mm	- 20 mm	- 25 mm

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15.3.9.8 Tolerance in dimensions of pocket:

20 mm overall maximum tolerance on the size of pocket.

For pockets, chemically dissolvable moulds shall be preferred. Smooth removal of moulds without affecting the pocket size shall be ensured.

16.0 INSPECTION AND TESTING OF STRUCTURES

16.1 Inspection

To ensure that the construction complies with the design, an inspection procedure shall be set up by the contractor and duly approved by the Engineer-in Charge covering materials used, receipt of materials, their test results, records, workmanship and construction etc.

Contractor shall ensure that the surface which is to receive the grout is at proper level and so are the openings for pockets as per Cl. 15.3.9.7 & 15.3.9.8.

16.2 Immediately after stripping the formwork, all concrete shall be carefully inspected and any defective work or small defects either removed or made good before concrete has thoroughly hardened.

16.3 Testing

In case of doubt regarding the grade or soundness of concrete used, either due to poor workmanship or based on results of cube strength, compressive strength tests of concrete on the basis of clause 17.4 of IS 456 and/or load test as per clause 17.6 of IS 456 shall be carried out.

The Engineer-in-Charge shall be the final authority for interpreting the results of all tests and shall decide upon the acceptance or otherwise. The decision of the Engineer-in-Charge shall be final and binding on the contractor. In case the results of the tests are unsatisfactory, the Engineer-in-Charge may instruct the contractor to demolish and reconstruct the structure or part thereof without any extra cost to the Owner.

16.4 Members other than Flexural Members

Members other than flexural members like columns etc. shall be referred to the designer to investigate the structural adequacy. The decision of the designer shall be final and binding on the contractor.

16.5 Non-destructive Tests

Non-destructive tests using Ultrasonic Pulse Velocity and Rebound Hammer methods shall be resorted to for checking the soundness of concrete placed and shall be as per the directions of Engineer-in-Charge. The testing shall be based on IS 13311, Part-1. However, the Rebound Hammer test (IS 13311, Part-2) shall only be used in combination with other tests (Destructive or Non-Destructive) for checking the concrete quality.

17.0 FINISHING OF CONCRETE

17.1 On striking the formwork, all surface defects such as bulges, ridges and honey-combing etc. observed shall be brought to the notice of the Engineer-in-Charge. The Engineer-in-Charge may, at his discretion allow rectification by necessary chipping and packing or grouting with concrete or cement mortar. However, if honey-combing or sagging is of such extent as being undesirable, the Engineer-in-Charge may reject the work totally and his decision shall be binding. No extra payment shall be made for rectifying these defects, demolishing and reconstructing the structure. However, quantity of cement actually used for this purpose may

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be considered for reconciliation of materials. All burrs and uneven faces shall be rubbed smooth with the help of carborundum stone.

The surface of non-shuttered faces shall be smoothened with a wooden float to give a finish similar to that of the rubbed down shuttered faces. Concealed concrete faces shall be left as from the formwork except that honey-combed surface shall be made good as specified above. The top faces of slabs not intended to be covered shall be levelled and floated to a smooth finish to the rises or falls shown on the drawings or as directed. The floating shall not be executed to the extent of bringing excess fine materials to the surface. The top faces of slabs intended to be covered with screed, granolithic or similar finishes, shall be left with a rough finish.

17.2 Repair and Replacement of Unsatisfactory Concrete

17.2.1 Repair shall be made as soon as possible after the forms are removed and before the concrete becomes too hard with prior permission from the Engineer-in-Charge, in writing. Stone pockets, segregation patches and damaged areas shall be chipped out and the edges undercut slightly to form a key. All loose material shall be washed out before patching. No excess water shall be left in the cavity, but the concrete shall be damp. A good bond between the patch and parent concrete shall be obtained by sprinkling dry cement on the wet surface or by throwing mortar with force on to the wetted concrete, or by brush in a coat of thick cement grout of about 1:1 (1 cement:1 sand) just before applying the patching material. Before this has dried, the remainder of the patch shall be filled with mortar or concrete, depending on the extent of the repair.

17.2.2 Cement concrete/mortar used in repair of exposed surfaces shall be made with cement from the same source as that used in concrete and blended with sufficient amount of white Portland cement to produce the same colour as in the adjoining concrete. The proportions of ingredients shall be same as those used in parent concrete. The mortar shall be as dry as possible and well compacted into the cavity. All filling shall be tightly bonded to the concrete and shall be sound, free from shrinkage cracks after the filling has been cured and dried.

17.2.3 For larger repairs to hardened concrete, necessary formwork bearing tightly at the edges of the cavity shall be provided. Concrete shall be chipped out to a depth of at least 100 mm and preferably 150 mm. Mortar shall be scrubbed into all surfaces with a wire brush before placing the concrete. Damaged reinforcement shall be adequately spliced with new steel so as to maintain the original strength. Additional reinforcement, if required in the patch, shall be provided as per the instructions of Engineer-in-Charge.

17.2.4 In case, in the opinion of the Engineer-in-Charge, defects in the concrete is excessive or beyond repair, the contractor shall either redo the structure or take other remedial measures as instructed by the Engineer-in-Charge. The decision of the Engineer-in-Charge shall be final and binding to all in this respect.

17.2.5 Approved epoxy formulation for bonding fresh concrete used for repairs with already hardened concrete shall be used by the Contractor if asked by the Engineer-in-Charge. Epoxy shall be applied in strict accordance with EIL Specification 6-68-0056 and the instructions of the manufacturer.

17.2.6 All repair works due to non-conformance or non-adherence to specification, if allowed by the Engineer-in-Charge, shall be carried out free of cost to the owner.

17.3 Curing of Patched Work

Immediately after patching is completed, the patched area shall be covered with an approved non-staining water saturated material which shall be kept wet and protected against sun and wind for a period of 12 hours. Thereafter, the patched area shall be kept continuously wet by a fine spray or sprinkling for not less than 10 days.

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18.0 WATERPROOF CEMENT PAINT

Wherever specified, concrete elements (whether cast-in-situ or precast) exposed to atmosphere shall be provided with three coats of cement based waterproof paint as per IS 5410 provided these surfaces shall not contain any protective coating. Prior to application of the paint, the surface shall be prepared to remove all foreign particles, loose materials, extra deposited concrete lumps, etc. using appropriate mechanical/ manual means.

19.0 FORM WORK

19.1 General

19.1.1 Forms for concrete shall be of plywood conforming to IS 6461 (Part-5) or steel or as directed by the Engineer-in-Charge and shall give smooth and even surface after removal thereof.

19.1.2 If it is desired by Engineer-In-Charge, the Contractor shall prepare, before commencement of actual work, design and drawings for formwork and get them approved by the Engineer-in-Charge. For details regarding design, detailing etc., reference may be made to IS 14687.

19.1.3 Form work and its supports shall maintain their correct position and be to correct shape and profile so that the final concrete structure is within the limits of dimensional tolerances specified below, unless required otherwise, for functional/aesthetic reasons. The decision of the Engineer-in-Charge shall be final and binding in this regard.

(a) Deviation from specified dimensions of cross section of columns and beams. — - 5 mm to +10 mm

(b) Deviation from dimensions of footings (see Note below)

i)	Dimensions in plan	-10 mm to +50 mm
ii)	Eccentricity	0.02 times the width of the footing in the direction of deviation but not more than 50 mm.
iii)	Thickness	-10 mm to +50 mm or $\pm$0.05 times the specified thickness, whichever is less

Note: These tolerances apply to Cast-in-situ concrete dimensions only, not to positioning of vertical reinforcing steel or dowels.

(c) Deviation in length (major dimension of single unit)

upto 3m	$\pm$6 mm
3m to 4.5m	$\pm$9 mm
4.5m to 6m	$\pm$12 mm
Additional deviation for every subsequent 6m.	$\pm$6 mm

(d) Deviation in straightness or bow (deviation from specified line) for a single or continuous member) e.g. beam, column or slab edge.

upto 3m	6 mm
3m to 6m	9 mm
6m to 12m	12 mm
additional for every subsequent 6m.	6 mm

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(e) Deviation in squareness shall be measured taking the longer of two adjacent sides as the base line.

The shorter side shall not vary in its distance from a perpendicular so that the difference between the greatest and shortest dimensions exceeds 6 mm. For this purpose, any error due to lack of straightness shall be ignored. Squareness shall be checked with respect to the straight lines that are most nearly parallel with the features being checked. When the nominal angle is other than 90 degree, the included angle between check lines shall be varied accordingly.

(f) Deviation in twist shall be within a limit such that any corner shall not be more than the limit given below from the plane containing other three corners:

upto 600 mm wide and upto 6m in length	:	6 mm
over 600 mm wide and for any length	:	12 mm

(g) Maximum deviation in flatness from a 1.5m straight edge placed in any position on a nominally plain surface shall not exceed 6 mm.

(h) Tolerance in leveling of concrete surface at foundation/ pedestal top level where grouting is to be done : As per Cl. 15.3.9.7

19.2 Form Requirement

19.2.1 The formwork shall be true, rigid and adequately braced both horizontally as well as diagonally. The forms shall have smooth and even surface and be sufficiently strong to carry, without deformation, the dead weight of the green concrete, working load, wind load and also the side pressure exerted by the green concrete. As far as practical, clamps shall be used to hold the forms together. Where use of nails is unavoidable minimum number of nails shall be used. Projected part of nail shall not be bent or twisted for easy withdrawal.

19.2.2 Where through tie rods are required to be put to hold the formwork and maintain accurate dimension, they shall always be inserted through a precast concrete block (of same mix proportion as is to be used for concreting) with a through hole of bigger diameter. The Precast block shall tightly fit against in inner faces of formwork. The holes left after the withdrawal of tie rods shall be fully grouted with cement-sand mortar of same proportion as that used for concrete. However, use of such precast block shall in no case impair the desired appearance or durability of the structure. No such tie rods shall be used in any liquid retaining or basement structure.

19.2.3 Tie wires shall be permitted only upon approval of the Engineer-in-Charge and shall be cut off flush with the face of the concrete or counter sunk, filled and finished in the manner specified in clause 17.

19.2.4 Form joints shall not permit any leakage. The formwork shall be strong enough to withstand the effect of vibrations practically without any deflection, bulging, distortion or loosening of its components.

19.2.5 Forms for beams and slabs (span more than 6.0m) shall have camber of 1 in 500 so as to offset the deflection and assume correct shape and line after deposition of concrete. For cantilevers, the camber at free end shall be 1/100th of the projected length. Where architectural considerations and adjunctive work are critical, smaller form cambers shall be adopted as decided by the Engineer-in-Charge.

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19.2.6 All vertical wall forms may be designed and constructed for the following minimum pressure. The pressures listed in Table-6 are intended as guide only and the Contractor shall ensure that the formwork is adequately strong and sturdy.

TABLE - 6
MINIMUM DESIGN PRESSURE FOR WALL FORMWORK

Rate of pour in meter/hour	Pressure in KN/m^2	
	at 10^0 (in Celsius)	at 24^0 (in Celsius)
0.6	36.0	29.0
0.9	40.0	32.0
1.2	44.0	35.0
1.5	46.0	37.0

All horizontal forms shall be designed and constructed to withstand the dead load of the green concrete, reinforcement, equipment, material, embedment and a minimum live load of 2.0 kN/m^2.

19.3 Inspection of Forms

Temporary openings shall be provided at the base of column and wall forms and other places necessary to facilitate cleaning and inspection. Before concrete is placed, all forms shall be carefully inspected to ensure that they are properly placed, sufficiently rigid and tight, thoroughly cleaned, properly treated and free from foreign material. The complete form work shall be inspected and approved by the Engineer-in-Charge before the reinforcement bars are placed in position. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the work shall be stopped until the defects have been rectified as per the instructions of the Engineer-in-Charge.

19.4 Cleaning and Treatment of Formwork

The surfaces of forms that would come in contact with concrete shall be well treated with approved non-staining form release agents such as soft soap, oil, emulsions etc. Release agents shall be applied so as to provide a thin uniform coating to the forms without coating the reinforcement.

19.5 Chamfers and Fillets

All corners and angles shall be formed with 45 degree mouldings to form chamfers or fillets on the finished concrete. The standard dimensions of chamfers and fillets, unless otherwise detailed or specified shall be 25x25 mm. For heavier work chamfers or fillets shall be 50x50 mm. Care shall be exercised to ensure accurate mouldings. The diagonal face of the moulding shall be planed or surfaced to the same texture as the forms to which it is attached.

19.6 Reuse of forms

Before reuse, all forms shall be thoroughly scrapped, cleaned, examined and when necessary, repaired and retreated, before resetting. Formwork shall not be reused, if declared unfit or un-serviceable by the Engineer-in-Charge.

19.7 Removal of Forms/Stripping Time

In the determination of time for removal of forms, consideration shall be given to the location and character of the structures, the weather and other conditions including the setting and curing of the concrete and material used in the mix.

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Forms and their supports shall not be removed without the approval of the Engineer-in-Charge. Forms shall not be released until the concrete has achieved a strength of at least twice the stress to which the concrete may be subjected at the time of removal. The formwork shall be removed without shock and methods of form removal likely to cause over stressing or damage to the concrete shall not be adopted. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

In normal circumstances when average air temperature exceeds 15 degree Celsius during the period under consideration after pouring of concrete and where ordinary Portland cement is used, forms may generally be removed after expiry of following periods.

(a) Walls, columns and vertical faces of all structural members	16 to 24 hours as may be decided by the Engineer-in-Charge.
(b) Slabs (props left under)	3 days.
(c) Beam Soffits (props left under)	7 days.
(d) Removal of props under slabs:	
Spanning upto 4.5m.	7 days.
Spanning over 4.5m.	14 days.
(e) Removal of props under beams and arches:	
Spanning upto 6m	14 days.
Spanning over 6m	21 days

(f) Cantilever Construction Formwork shall remain till structures for counter acting or bearing down have been erected and have attained sufficient strength (minimum 14 days).

Notes:

i) For other cements, the stripping time recommended for ordinary Portland cement shall be suitably modified as per the instructions of the Engineer- in-Charge.

ii) The number of props left under, their sizes, supporting arrangement, and disposition shall be such as to be able to safely carry the full dead load of the slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

iii) Where the shape of the element is such that the formwork has re-entrant angles, the form work shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking occurring due to the restraint imposed.

iv) For rapid hardening cement, 3/7 of the above mentioned periods shall be considered subject to a minimum of 16 hours.

v) For Portland pozzolana or low heat cement, 10/7 of the above mentioned periods shall be considered.

19.8 Staging/Scaffolding

19.8.1 Staging/Scaffolding shall be properly planned and designed by the Contractor. Use of only steel tubes is permitted for staging/scaffolding. The Contractor shall get it reviewed by Engineer-in-Charge before commencement of work. While designing and during erection of scaffolding/staging, the following measures shall be considered:

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(a) Sufficient sills or underpinnings in addition to base plates shall be provided particularly where scaffolding is erected on soft grounds.

(b) Adjustable bases to compensate for uneven ground shall be used.

(c) Proper anchoring of the scaffolding/staging at reasonable intervals shall be provided in each direction with the main structure wherever available.

(d) Horizontal braces shall be provided to prevent the scaffolding/staging from rocking.

(e) Diagonal braces shall be provided continuously from bottom to top between two adjacent rows of uprights.

(f) The scaffolding/staging shall be checked at every stage for plumb line.

(g) Wherever the scaffolding/staging is found to be out of plumb line it shall be dismantled and re-erected afresh and effort shall not be made to bring it in line with a physical force.

(h) All nuts and bolts shall be properly tightened and care shall be taken that all clamps/couplings are firmly tightened to avoid slippage

(i) Erection work of a scaffolding/staging under no circumstances shall be left totally to semi-skilled or skilled workmen and shall be carried out under the supervision of a technically qualified civil engineer of the Contractor.

19.8.2 For smaller works or works in remote areas, wooden ballies may be permitted for scaffolding/staging by the Engineer-in-Charge at his sole discretion. The contractor must ensure the safety and suitability of such works as described under clause 19.8.1 above.

20.0 EXPOSED/ARCHITECTURAL CONCRETE WORK

20.1 Form Work

Other things remaining same as per clause 19.0, formwork shall be of high quality. Care shall be taken to arrange the forms so that the joints between forms correspond with the pattern indicated in the drawings. The forms shall be butting with each other in straight lines, the corners of the boards being truly at right angles. The joints between the forms shall cross in the two directions at right angles. The size of forms shall be so selected as to exactly match with the pattern of forms impression on the concrete face indicated in the drawings. Maximum care shall be taken to make the form work watertight. Burnt oil shall not be used for treatment of forms. The Contractor shall be permitted reuse of forms brought new on the work place only if forms are properly cared for, stored and treated after each use.

The Engineer-In-Charge may, at his absolute discretion, order removal of any forms considered unsuitable for use in the work.

20.2 Finishing

Repairing to exposed concrete work shall be avoided. Rendering and plastering shall not be done. Minor repairing, if unavoidable shall be done as specified in clause 17.0 with the written permission of the Engineer-in-Charge.

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21.0 REINFORCEMENT

21.1 The Contractor shall develop the bar bending schedule for all RCC structures/ structural parts at no extra cost to the Owner and shall get it reviewed by the Engineer-in-charge. Reinforcement shall be cut and bent to shape as per dimensions shown in the bar bending schedule/ drawings.

If protective fusion bonded epoxy coating is required to be applied on reinforcement bars, the same shall be done as per IS 13620. All repairs to applied protective coating required due to mishandling and/ or bending of reinforcement bars shall also be done as per relevant clauses of IS 13620.

21.2 Straightening, Cutting and Bending

Procedure for cutting and bending shall be as given in IS 2502. Bars shall be bent in a slow and regular movement to avoid fractures by mechanical means only. In case bars are supplied in coils, they shall be smoothly straightened without any kinks.

Cold twisted deformed bars shall be bent cold. Bars larger than 25 mm in size (except cold twisted deformed bars) may be bent hot at cherry red heat to a temperature not exceeding 850^0 Celsius as per the instructions of the Engineer-in-Charge. The bars shall be allowed to cool gradually without quenching.

Bars shall be cut & bend in a Bar Bending Machine. Bars which develops cracks or splits after bending shall be rejected. A second bending of reinforcement bars shall be avoided but when reinforcement bars are bent aside at construction joints and afterwards bent back into their original position, care should be taken to ensure that at no time is radius of the bend less than 6 times bar diameter for high strength deformed bars. Care shall also be taken when bending back the dowel bars to ensure that concrete around the bars is not damaged. All bars shall be properly tagged for easy identification.

21.3 Placing and Fixing

All reinforcement shall be cleaned to ensure freedom from loose mill scale, loose rust, oil, form releasing agents, grease or any other harmful material before placing them in position. Reinforcement shall not be surrounded by concrete unless it is free from all such materials. Rough handling and dropping of reinforcement from a height shall be avoided.

All reinforcement shall be fixed in the correct position and shall be properly supported to ensure that displacement will not occur when the concrete is placed and compacted.
The uncoated reinforcement bars shall be tied at every intersection by two strands of 16 SWG black soft annealed binding wire. The Epoxy coated reinforcement bars shall be tied with 2 strands of PVC coated GI 18 SWG wire at every intersection. Crossing bars shall not be tack welded for assembly of reinforcement. The reinforcement bars shall be kept in position by using the following methods:

a) In case of beam and slab construction, precast cover blocks (having the same sand contents as the concrete which shall be placed) of size 40 x 40 mm and thickness equal to the specified covers shall be placed firmly in between the bars and forms so as to secure and maintain the specified covers over the reinforcement.

When reinforcement bars are placed in two or more layers in beams, the vertical distance between the horizontal bars shall be maintained by introducing spacer bars at 1 to 1.2m centre to centre.

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b) In case of thick rafts & pile caps having two or multi layers of reinforcement, the vertical distance between the horizontal bars shall be maintained by introducing suitable chairs, spacers, etc.

c) In case of columns and walls, the vertical bars shall be kept in position by means of timber templates with slots accurately cut in them. The templates shall be removed after the concreting has been done below it.

d) Exposed portions of reinforcement bars shall not be subjected to impact or rough handling and workmen will not be permitted to climb on extending bars until the concrete has attained sufficient strength so that no movement of the bars in the concrete is possible.

21.4 Special requirements for Handling, Stacking, Placing of Epoxy coated Reinforcing bars.

Epoxy coated reinforcing bars shall be carefully handled and it shall be ensured that these do not rub on any hard surface or against another epoxy coated/uncoated reinforcing bar whether during conveying/transportation, stacking or placing.

During transportation and while stacking the epoxy coated reinforcing bars shall be placed on wooden planks not spaced farther than 600 mm. When placed in stacks the epoxy coated reinforcing bars shall be neatly tied in bundles using PVC binding material.

The cut ends of bars shall be touched up with special touch up material of specifications as provided by the coating agency. After cutting of the bar the application of touch up material shall be completed within four hours.

While bending the bars the pins of work bench(s) shall be provided with a PVC or plastic sleeve. Each bending operation on epoxy coated reinforcing bar shall be completed in time not less than 90 seconds.

Epoxy coated reinforcing steel bar shall not be directly exposed to sun rays or rain, and shall be protected with opaque polyethylene sheets or similar means as approved by the Engineer in Charge.

While doing concreting the workmen or machinery shall not rest or move on the epoxy coated reinforcing bars. Wooden planks shall suitably be placed to create proper gang-way.

21.5 Splicing/Overlapping

Only bars of full length shall be used as shown in the drawings. But where this cannot be done, overlapping of bars shall be done as directed by the Engineer-in-Charge. The overlapping bars shall be tied with two strands of 16 SWG black soft annealed binding wire. The overlaps shall be staggered for different bars and located at points along the span where neither shear nor bending moment is maximum.

21.6 Welded Joints

Welding of reinforcing bars shall not be permitted without the written permission of the Engineer-in- Charge. Where welding of reinforcing bars is permitted, it shall be in accordance with the recommendations of IS 2751 and IS 9417. Welded joints shall be located at suitable staggered positions. Tests shall be made as directed by the Engineer-in-Charge to prove that the joints are of the full strength of the bars. Maximum one welded joint shall be allowed per bar.

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21.7 Mechanical Connections

The mechanical splices in reinforcement by means of couplers, clamps etc. shall be used (as per manufacturer's specifications) with the written approval of the Engineer-in-Charge. Following tests, at the minimum, shall be conducted in advance to prove efficiency of the coupled joint before putting them in actual use. This covers requirements of couplers to be used with bars conforming to grades less than & equal to Fe550D of IS 1786.

Name of the Test	Testing Requirement	Code of conformance
Static Tensile test: 1. Tensile strength	Each connection shall develop at least 125% of the specified yield strength of the reinforcing bar & 100% of the specified tensile strength. Bar break requirement shall be satisfied to avoid splice failure & to develop full tensile strength of the bar.	ASTM A370/ ACI 318/ **AC 133**/ ISO 15835/ IS 16172
Static Tensile test: 2. Percentage elongation (Ductility)	The minimum percentage elongation (at maximum forces), in the reinforcing bar outside the length of the mechanical splice shall be minimum 3% before the failure of the test piece.	ISO 15835 IS 16172
Static compression test	Each connection shall develop atleast 125% of the specified yield strength of the reinforcing bar.	ASTM A370/ ACI 318/ AC 133
Permanent Elongation (Slip)	Permanent elongation across the coupled joint shall be less than 0.1 mm after loading at 60% of the yield strength of the reinforcing bar	BS 8110/ ISO 15835 IS 16172
Cyclic tensile test	Mechanical splice shall withstand 100 cycles of stress variation from 5% to 90% of the yield strength of reinforcing bar & without loss of static tensile strength capacity when compared with like specimen.	IS 16172
Moderate Oligocyclic (Seismic) Test (Cyclic Tension & Compression Test) **(Refer note- 1)**	Deformation across the coupled joint shall be less than 0.3 mm after subjecting the joint to a series of 20 cycles with 95% tension as well as 50% compression of the yield strength of the reinforcing bar & without loss of static tensile strength capacity when compared with like specimen.	ISO 15835/ ASTM A370/ ACI 318/ AC 133
Violent Oligocyclic (Seismic) Test (Cyclic Tension & Compression Test) **(Refer note- 2)**	The joint shall be subjected from zero strain upto twice the yield strain in tension followed by compression stress of 50% of yield strength of reinforcing bar for 4 cycles. Thereafter, from zero strain upto five times the yield strain in tension followed by compression stress of 50% of yield strength of reinforcing bar for 4 cycles. Deformation across the coupled	ISO 15835/ ASTM A370/ ACI 318/ AC 133

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Name of the Test	Testing Requirement	Code of conformance
	joint shall be less than 0.3 mm after 4 cycles & less than 0.6 mm after 8 cycles & without loss of static tensile strength capacity when compared with like specimen.	
Low cycle fatigue test **(Refer note- 3)**	Mechanical splice shall withstand 10,000 cycles of alternating tension & compression load from +173Mpa to -173Mpa & without loss of static tensile strength capacity when compared with like specimen.	IS 16172

Notes-

1) Moderate Oligocyclic (Seismic) test shall be performed for structures in seismic zone II.

2) Violent Oligocyclic (Seismic) test shall be performed for structures in seismic zone III, IV & V.

3) Low cycle fatigue test shall be performed for all structures except for concrete structures which are subjected to high cycle of fatigue like machine foundations etc.. For concrete structures which are subjected to high cycle of fatigue, High cycle fatigue test shall be performed as per IS 16172.

All operations relating to reinforcement coupling shall be done by using manufacturer's patented machine/ equipment in the presence of Engineer-in-Charge. Mechanical connections shall be placed away from points of high stress and shall be staggered.

21.8 Tolerances on Placing of Reinforcement

Unless otherwise directed by the Engineer-in-Charge, reinforcement shall be placed within the following tolerances:

a) For effective depth 200 mm or less $\pm$ 10 mm

b) For effective depth more than 200 mm $\pm$ 15 mm

21.9 Substitution

When indicated diameter of reinforcement bar is not available, the Contractor shall use other diameter of reinforcement bars on written approval of the Engineer-In-Charge.

21.10 Tolerance to Cover

The actual concrete cover shall not deviate from the required nominal cover by + 10 mm measured over the steel reinforcement including links.

22.0 PAYMENT

22.1 Plain and Reinforced Concrete

22.1.1 Payment for plain and reinforced cement concrete shall be made on cubic metre basis of the volume of the actual finished work done or as per approved construction drawings, whichever is less and shall be inclusive of providing pockets, openings, recesses of all sizes, chamfers, fillets, grooves, separation/ expansion/ isolation/ construction/ movement joints, curing by normal moist curing or using curing compound etc. as directed by Engineer-in-Charge etc. The rates shall be deemed to include complete cost of getting the

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respective mix designs approved, making and testing concrete cubes and carrying out other tests including tests of various ingredients, as per specifications and as directed by Engineer-in-Charge. Payment shall, however, be separately made for tests on concrete cubes done by accelerated methods of curing as defined in IS 9013.

22.1.2 No separate payment shall be made for any additive/ admixture/ Plasticizer/ Fibres used by the contractor for accelerating or retarding the strength of concrete or for achieving specified workability. The rate quoted shall be deemed to be inclusive of all costs related to any such additive/admixture/ Plasticizer/ Fibres.

22.1.3 The rate shall however be exclusive of reinforcement, metal inserts, pipe sleeves, formwork, water stops and any filler material in expansion/isolation joints.

22.1.4 Where the strength of concrete mix as indicated by tests, lies in between the strengths of any two grades given in Table-1 and it is accepted by the Owner/Engineer-in-Charge, such concrete shall be classified as a grade belonging to the lower of the two grades between which it lies. In case the cube strength shows higher results than those specified for the particular grade of the concrete, it shall not be placed in the higher grade nor shall the Contractor be entitled for any extra payment on such account. The concrete giving lower strength than specified may be accepted at reduced rates after satisfying the safety of the structure by checking it with tests as specified or rejected entirely at the discretion of the Engineer-in- Charge. The rejected concrete shall be dismantled at no extra cost to the owner and no payment or extension of time shall be granted for the concrete so rejected and the formwork and reinforcement used for the same. Cost of any material supplied by the Owner free of cost shall be recovered from the Contractor at double the prevailing market rate. In case the concrete of lower strength can be improved by carrying out some strengthening measures entirely at the discretion of the Engineer-in-Charge, then the said measures including all related tests shall be carried out by Contractor at his own cost. If the Contractor is able to make up the strength to the required grade by such improvement measures to the entire satisfaction of Engineer-in-Charge, payment shall be made for the grade achieved. However, if the strength of concrete is not made up to the strength of required grade, payment shall be made only for the lower strength if such concrete is accepted by the Engineer-in-Charge.

22.1.5 Deductions for openings, pockets etc. shall be as specified in relevant parts of IS 1200.

22.1.6 The rate quoted for reinforced cement concrete, also includes single pour concreting wherever specified. The rate shall be inclusive of all extra cost related to labour, shuttering, staging and making all other arrangements for such continuous casting e.g. provisions for adequate movement and storage spaces, special gangways, scaffolding, additional construction equipments, adequate lighting and supervision while the work continues round the clock etc. The rate shall also be inclusive of all costs related to concreting in any thickness, shape and position and at any height or depth so as to avoid any cold joint between specified construction joints.

22.1.7 Form Work

Unless otherwise specified, payment for form work shall be on square metre basis of the actual area in contact with the concrete cast. The rates shall be inclusive of keeping the formwork for the full period as specified in the above clauses and removing the same after the period is over. No extra payment shall be made for providing scaffolding/ staging/ access/ stairways/ ladders etc.

The rates shall be inclusive of any provision to be made or kept in the formwork for providing dowels, inserts etc.

Superior quality formwork for exposed/architectural concrete work shall be measured and paid separately under the relevant item in the schedule of rates.

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22.2 Reinforcement

22.2.1 Payment for plain round mild steel reinforcement bars, high strength deformed steel bars and epoxy coated reinforcing steel bar shall be on the basis of weight of bare steel irrespective of any coating applied in metric tons. The weight of the bar shall be derived from the sizes and corresponding nominal unit weight given in Table-1 of IS 1786. In case actual unit weight of the bars is less than nominal unit weight, but within permissible tolerances, the weight of reinforcement shall be calculated on the basis of actual unit weight. In case actual unit weight of the bars is more than nominal unit weight, the payment shall be made on the basis of nominal unit weight. Standard hook lengths, chairs, spacer bars and authorized laps only shall be included in the weight calculated. Binding wire shall not be weighed nor otherwise measured. Measurements for weight shall not include cutting allowance etc.

22.2.2 Rate quoted for reinforcement shall include cost of supplying, decoiling, straightening, cleaning, cutting, bending, placing, binding, welding (if required) and providing necessary cover blocks of concrete.

22.2.3 Payment for a mechanical threaded coupler/ clamp shall be made by measuring the Lap length of the respective rebar on which coupler/ clamp is used. The rate shall include supply of complete assembly, fixing, testing etc. all complete.

22.3 Water Stops/Water Bars & Expansion/Isolation Joints

22.3.1 Payment for water bars shall be made on running metre (RM) basis of the water stops provided in position. Rate shall include supplying, cutting, fixing, jointing by vulcanising or any other approved method, wastage, etc. complete.

22.3.2 Payment for filler materials in Expansion/Isolation joints shall be made on running metre basis of the joint provided. For boards provided at expansion/isolation joints, the measurement shall be made on square metre basis. Rate shall be inclusive of supply, cutting, fixing, jointing, wastage etc. complete.

22.4 Waterproof Cement Paint

22.4.1 Payment for waterproof cement paint as per Cl. 18.0 shall be made separately on Sqm basis.

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मानक विनिर्देशन
सिविल एवं संरचनात्मक कार्य

STANDARD SPECIFICATION
CIVIL AND STRUCTURAL WORKS

जलीय तरल पदार्थों को धारण करने वाली संरचनाओं के लिए पुनर्बलित सीमेंट कंक्रीट

REINFORCED CEMENT CONCRETE FOR STRUCTURES RETAINING AQUEOUS LIQUIDS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
7	30.12.25	UPDATED & ISSUED	AS	ASR	AS	MN
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Abbreviations:

BIS : Bureau of India Standards

IS : Indian Standards

Structural Standards Committee

Convener: Mr. Anurag Sinha

Members:
Mr. Virender Goel
Mr. Deepak Agrawal
Ms. Alpana Srivastava
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CONTENTS

1.0 SCOPE 4

2.0 REFERENCES 4

3.0 MATERIALS 4

4.0 GENERAL REQUIREMENTS 4

5.0 CONCRETE 4

6.0 RENDERING 6

7.0 SEPARATION LAYER 6

8.0 FORM WORK 6

9.0 CURING 7

10.0 FINISHES 7

11.0 HYDRAULIC TESTING 7

12.0 PAYMENT 7

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1.0 SCOPE

1.1 Concrete structures meant for retaining aqueous liquids shall include under/ overground reservoirs/ tanks, sumps, channels, launders, swimming pools etc. which are required to retain any aqueous liquids internally. In case referred in drawings, this specification shall also be applicable for basements, tunnels, ducts, trenches etc. which are in direct contact with sub-soil water from the outside.

2.0 REFERENCES

2.1 BIS Codes

IS 1838 (Parts 1-3), 2645, 3370 (Parts 1-4), 6494, 9103, 12118 (Parts 1-2)

2.2 EIL Specifications & Standards

6-68-0002 : Materials
6-68-0004 : Plain and Reinforced Cement Concrete
7-68-0631 : Liquid retaining Structures- Concrete Joints

3.0 MATERIALS

3.1 Materials for concrete viz. cement, sand, aggregate, water etc., admixtures and water stops shall be as described in EIL specification no. 6-68-0002.

4.0 GENERAL REQUIREMENTS

4.1 The concrete structure by itself shall be leak proof to the extent as acceptable (refer Cl. 11.0). Damp patches, if any at the initial stage, shall not be acceptable if the same do not disappear after three months of putting the structure in service. The basic requirement is to make the concrete sound, dense and impervious. The Contractor shall take all necessary precautions in selecting the materials, mix design and method of construction so as to achieve this objective. If any additional protective layer of liquid-proofing material such as coating, tiles, membrane, lining etc. is specified and/ or shown on drawings, the same shall be considered as a second line of defence and shall not entail the contractor to any relaxation from the conditions for the structure being leakproof by itself.

4.2 This specification defines the minimum requirements regarding materials, construction and performance for concrete structures retaining aqueous liquids. Any special/ extra requirements as shown or noted in the drawings shall have precedence over the provisions of this specification.

4.3 The work shall be done in accordance with this specification read together with references as per Cl.2.0 of this specification. In case of conflict between this specification and the Indian Standards, this specification shall govern.

4.4 After construction, the structure shall be tested for being watertight/ leakproof as detailed subsequently in this specification.

5.0 CONCRETE

5.1 EIL specification no. 6-68-0004 shall be applicable together with the following clauses:

5.1.1 Special care shall be taken to get the most suitable grading of aggregates so as to produce the densest possible concrete. The maximum size of coarse aggregate shall be limited to 20 mm, unless shown on the drawing. Water-cement ratio shall be strictly controlled (by making due

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allowance for the surface water carried by the aggregates), consistent with the requirement of workability to produce an impervious concrete.

5.1.2 Minimum Grade of Concrete shall be as per IS 3370.

5.1.3 Concrete shall have minimum cement content and maximum water cement ratio as per IS 3370. In order to achieve required workability and slump, cement and water content may be suitably adjusted, keeping the water cement ratio constant.

5.1.4 Water proofing compound of approved make, conforming to IS 2645, shall be mixed with concrete in proportion as per manufacturer's specification.

5.1.5 The joints of shuttering board shall be made tight to produce a face free from pores.

5.1.6 The concrete shall be so placed and vibrated that a well compacted dense concrete free from honeycombing is produced.

5.1.7 **Admixtures**

Admixtures in concrete shall be used only with the prior approval of the Engineer-in-Charge. Any admixture used for obtaining proper workability or leak-proofness of concrete or repair/ rendering works of concrete due to non-conformance to the EIL specifications, shall not be measured and paid for. All costs relating to such usage shall be borne by the Contractor.

5.1.8 Concreting with Self Compacting Concrete (SCC) conforming to EIL Specification No. 6-68-0019 shall be preferred.

5.2 Construction, Contraction & Expansion Joints

For joint details, EIL Standard No. 7-68-0631 shall be referred in-addition to following:

5.2.1 All vertical and horizontal joints in structures retaining aqueous liquids shall be located and executed as shown in the drawings. For construction joints not shown in the drawing, specific approval of the Engineer-in-Charge shall be obtained. Every endeavour shall be made to avoid vertical construction joints. The number of construction joints shall be kept to a minimum. Where horizontal or vertical joints are required to be left in position after the day's work, the same shall be done as per directions of the Engineer-in-Charge. The face of the old concrete shall be well hacked to expose the aggregate, care being taken to avoid damaging the aggregate.

While the remainder of the concrete should be kept continuously wet, curing of the joint surface may be suspended a few hours before concreting is to be resumed so as to permit no more than superficial drying of the joint surface. Just before concreting is resumed, the roughened joint surface shall be thoroughly cleaned and freed from loose pieces of gravel, stone chips, wooden chips, nails, laitance or any other foreign material, preferably, without re-wetting, and then treated with a thin layer of cement grout, worked well into the surface, or treated with cement-sand mortar in which water-cement and sand-cement ratios do not exceed those in the new concrete.

5.2.2 Horizontal joints in vertical walls of the structure shall preferably form a closed loop.

5.2.3 Water stops installation shall be done by embedding one half of the water stop along the proposed joints on each side of the joint by suitable jigs/ factory-made preformed eyelets (already attached and usually supplied with water stop rolls)/ other supporting arrangement between the adjacent sections of the concrete as per the manufacturer's specification and directions of the Engineer-in-Charge. Water stops shall be positioned accurately and

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supported against any displacement during concreting. All precautions shall be taken to avoid folding or twisting of water stops during pouring and compacting concrete. To achieve the continuity of the water stop all along the joint, at crossings and at change of alignments, the water stops shall be joined/ vulcanized as per manufacturer's specifications and directions of the Engineer-in-Charge. Jigs manufactured out of reinforcing bars may be used for fixing the water stop. The jigs shall be measured and paid under reinforcement item.

5.2.4 Expansion joints shall be filled up with non-absorbent compressible sheet/bitumen impregnated fibre board (as per IS 1838) except the top 12mm depth on the water faces (or as shown on the drawings) which shall be filled with two-part liquid polysulphide sealant (as per IS 12118). In case of contraction and/or construction joints, such polysulphide sealant shall be used for 12mm depth on the water faces (or as shown on the drawings) after forming suitable grooves in concrete.

5.3 Items Embedded in Concrete

5.3.1 All sleeves, inserts, anchors and embedded items required for the work shall be available at site prior to start of concreting. These shall be accurately placed and embedded as described in EIL specification no. 6-68-0004. In case any protective coating for such elements is shown, Contractor shall coat the same prior to embedment, which shall be paid separately.

5.3.2 Every precaution shall be taken to keep all embedded items and water stops in position as shown on drawings during pouring and compacting concrete. Work in such areas shall be carried out under strict supervision.

6.0 RENDERING

6.1 Rendering by cement-sand mortar of same proportion as in original concrete shall be used with the object of covering weak patches in the construction, as per the direction of the Engineer-in-Charge. The rendering shall be applied to the concrete only after the inspection by the Engineer-in-Charge and if approved by him. The concrete surface shall be well wetted and if necessary, hacked prior to the application of mortar. The mortar shall be steel trowelled and finished with a wooden float.

7.0 SEPARATION LAYER

7.1 A separation layer shall be provided between the lean concrete and the bottom raft/ slab of the underground structure retaining aqueous liquids. This layer shall consist of a polyethylene sheet having a minimum thickness of 1000µm (corresponding to an approximate mass of 1 kg/m^2) conforming to IS 2508. The top surface of lean concrete shall be finished smooth (float finish) with a wooden trowel to receive the separation layer. Joints in the separation layers shall be lapped by 200mm. All care shall be taken to keep the separation layer in position while progressing with further work above.

8.0 FORMWORK

8.1 EIL specification no. 6-68-0004 for Plain & Reinforced Cement Concrete shall be applicable together with the following:

8.1.1 Detailed dimensioned drawing showing the arrangement of formwork, including its design if so required by the Engineer-in-Charge, shall be furnished to the Engineer-in-Charge before the formwork is erected. The work shall be as per the directions and approval of the Engineer-in-Charge. No concrete element of the structure retaining aqueous liquids shall be loaded with any support for further formwork unless it has aged for a minimum of 21 days. After that if any formwork rests on such element, adequate external support shall be provided so that any unequal loading on the element does not cause any local deformation.

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9.0 CURING

Concrete shall be cured in accordance with the EIL specification no. 6-68-0004 for Plain & Reinforced Cement Concrete.

10.0 FINISHES

10.1 All the formwork shall be so placed that no plastering or other external finish is required. All burrs shall be rubbed smooth with carborundum stone and the finished work shall present a uniform shade and finish. All the exposed surfaces shall be provided with a coat of cement wash free of cost if the rendered surfaces are not of acceptable standard as per the sole discretion of the Engineer-in-charge.

11.0 HYDRAULIC TESTING

11.1 Structures retaining aqueous liquids shall be tested strictly in accordance with IS 3370 for watertightness in addition to the structural tests as mentioned in EIL specification no. 6-68-0004. The total maximum drop in water surface level shall not exceed 6mm in 24 hours in case of covered reservoirs and 12mm in 24 hours in case of open reservoirs.

11.2 If the test results indicate that the structure is defective, the Contractor shall rectify/ repair the same at his own cost as per the approved scheme as agreed to by the Engineer-in-Charge. After such rectification/ repair, the structure shall be re-tested as per Cl. 11.1 above. If the structure still does not satisfy the acceptance criteria, the same shall be demolished and reconstructed within the specified time schedule, at Contractor's cost.

11.3 All testing after construction and remedial treatments shall conform to the provisions of IS 6494.

11.4 Backfilling around underground structures shall be allowed only after the test results are found satisfactory by the Engineer-in-Charge.

12.0 PAYMENT

This clause shall apply to Item Rate tenders only.

12.1 Payment shall be made on cubic metre (m^3) basis of the volume of the actual finished concrete work done or as per approved construction drawings, whichever is less. The rate shall be inclusive of all labour, material, curing, cost of leaving pockets, block-outs for pipes/ electric conduits, recesses of all sizes, embedded items, vibrating, rendering, hacking and washing old concrete faces, applying mortar/ grout on them, etc. but exclusive of reinforcement, formwork, embedded items, water stops and sealing compound which shall be paid under separate items. In case the Contractor proposes to use any admixture in concrete for making it watertight/ leakproof, no separate payment for such admixtures shall be made and the rate quoted for concrete under structures retaining aqueous liquids shall be inclusive of such admixtures. However, when such admixtures are used under EIL specific requirements mentioned in the drawings/ EIL specifications, these shall be separately measured and paid for, under the respective item/(s) in accordance with the Schedule of Rates.

12.2 No separate payment shall be made for testing and report preparation, which is deemed to be included in the quoted concrete rate, including the cost of hydraulic tests and structural tests, all appliances and rectifications, if any.

12.2.1 If the test results indicate that the structure is defective, the Contractor shall develop and execute with the approval of the Engineer-in-Charge, a suitable remedial scheme for making

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the structure watertight/ leakproof at his own cost. Even after carrying out such remedial scheme, if the retest results are unsatisfactory, the Contractor shall have to demolish and reconstruct the structure within the specified time schedule, at his own cost.

12.2.2 The cost of initial and subsequent testing, inclusive of cost of water, shall be borne by the Contractor. The Contractor shall make his own arrangement for filling as well as emptying the reservoir after the completion of the test and no payment shall be made on this account.

12.3 Payment for separation layer shall be based on the actual surface area measured in square metre (m^2). The Contractor shall include in his rate all allied works viz. supply of material, cleaning, preparing of surfaces, laying etc. all complete.

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मानक विनिर्देश
सिविल एवं संरचनात्मक कार्य

STANDARD SPECIFICATION
CIVIL & STRUCTURAL WORKS

संरचनात्मक इस्पात कार्य

STRUCTURAL STEEL WORKS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
8	13.05.25	UPDATED & REISSUED	RIYA	VIKRAM	AS	MN
7	13.01.20	UPDATED & REISSUED	TK	AJS	RS	RK TRIVEDI
6	26.08.14	UPDATED & REISSUED	SP	AS	PKM	S CHANDA
5	18.06.09	REAFFIRMED & REISSUED	AS	PKM	VINAY KUMAR	N. DUARI
4	18.04.00	UPDATED & REISSUED	DPN	RS	SCJ	MI
3	MAY'94	UPDATED & REISSUED	DPN	RS	GPL	A. SONI

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Abbreviations:

AFC	:	Approved For Construction
AWS	:	American Welding Society
BIS	:	Bureau of Indian Standards
IS	:	Indian Standards

Structural Standards Committee:

Convenor: Mr. Anurag Sinha

Members:
Mr. Virender Goel
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CONTENTS

1.0 SCOPE 4
2.0 REFERENCE 4
3.0 MATERIALS 4
4.0 FABRICATION DRAWINGS 5
5.0 FABRICATION 7
6.0 MARKING FOR IDENTIFICATION 16
7.0 SHOP ERECTION 16
8.0 INSPECTION & TESTING OF STRUCTURES 16
9.0 SHOP PAINTING 16
10.0 PACKING 17
11.0 TRANSPORTATION 17
12.0 SITE (FIELD) ERECTION 17
13.0 SAFETY & SECURITY DURING ERECTION 18
14.0 FIELD CONNECTIONS 18
15.0 GROUTING 18
16.0 SCHEME AND SEQUENCE OF ERECTION 19
17.0 PAYMENT 19
18.0 PAINTING AFTER ERECTION 20
ANNEXURE-'A' 23
ANNEXURE-'B' 25

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1.0 SCOPE

This specification describes the information to be included in a Project Specification and also covers the requirements for material, storage, preparation of fabrication drawings, fabrication, assembly, tests/examinations, transportation, erection and painting of all types of bolted and/or welded structural steel works for general construction work. Fabrication of structures shall also include fabricating:

(a) Built up sections/plate girders made out of rolled section and/or plates.

(b) Compound sections made out of rolled sections.

2.0 REFERENCES

2.1.1 BIS Codes

IS 800, IS 808, IS 816, IS 819, IS 822, IS 919, IS 1024, IS 1261, IS 1323, IS 1477, IS 1852, IS 2074, IS 7205, IS 7215, IS 7307, IS 7310, IS 7318, IS 9595 and other relevant BIS Codes.

2.1.2 International Standard

AWS D1.1 Structural Welding Code - Steel

2.2 EIL Specifications

6-68-0002- Materials
6-79-0020 (or relevant Job Specification) – Surface preparation & protective coating

2.3 In case of conflict between the clauses mentioned in this specification and those in the Indian Standards, this specification shall govern. Any special provision as shown or noted on the design drawings or any project specific specification specified elsewhere shall govern over the provisions of this specification.

3.0 MATERIALS

3.1 General

All materials shall conform to their respective specifications given in EIL Specification no. 6-68-0002. The use of equivalent or alternative materials shall be permitted only in very special cases and for all such cases prior written approval of the Engineer-in-Charge shall be obtained.

3.2 Receipt & Storing of Materials

3.2.1 Each section shall be marked for identification and each lot shall be accompanied by manufacturer's quality certificate, chemical analysis and mechanical characteristics.

3.2.2 All sections shall be checked, sorted out and arranged by grade and quality in the store. Any instruction given by the Engineer-in-Charge in this respect shall be strictly followed.

3.2.3 All material shall be free from surface defects such as pitting, cracks, laminations, twists etc. Defective material shall not be used and all such rejected material shall be immediately removed from the store/site. The decision of the Engineer-in- Charge in this regard shall be final and binding.

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3.2.4 Welding wires and electrodes (packed in their original cartons) shall be stored separately by quality and lots inside a dry and enclosed room in compliance with IS 9595 and as per the instructions given by the Engineer-in-Charge. Electrodes shall be kept perfectly dry to ensure satisfactory operation and weld metal soundness.

3.2.5 Each lot of electrodes, bolts, nuts etc. shall be accompanied by manufacturer's quality/test certificates.

3.2.6 All bolts (including nuts & washers) shall be checked, sorted out and arranged diameter-wise by grade and quality in the store.

3.3 Material Tests

3.3.1 The Contractor shall submit manufacturers' quality certificates for all the materials supplied by him. In case, quality certificates are not available or are incomplete or when material quality differs from standard specifications, such materials shall not be used in the construction. However, the Contractor shall get all appropriate tests conducted in approved test houses for such materials as directed by the Engineer-in-Charge, at no extra cost, and submit the same to Engineer-in-Charge for his approval. The Engineer-in-Charge may approve the use of such materials entirely at his discretion.

3.3.2 The Contractor shall ensure that all materials brought to site are duly approved by the Engineer-in-Charge. Rejected materials shall not be used and shall be removed from site forthwith. Any material of doubtful quality for which specific tests are to be carried out as per the instruction of the Engineer-in-Charge shall be separately stacked and properly identified and shall not be used. These shall be removed from site forthwith.

4.0 FABRICATION DRAWINGS

4.1 Fabrication and erection drawings shall be prepared by the Contractor on the basis of "Approved for Construction" (AFC) design drawings, EIL Standards issued to the Contractor. These drawings shall be prepared by Contractor or by an agency engaged by the contractor using TEKLA or AUTODESK Advance Steel or equivalent 3D Modeling software and approved by the Engineer-in-Charge.

4.2 Fabrication and erection drawings shall be thoroughly checked, stamped "Approved for Construction" and signed by the Contractor's own responsible Engineer irrespective of the fact that such drawings are prepared by the Contractor or his approved agency, to ensure accuracy and correctness of the drawings. Unchecked and unsigned drawings shall not be used for the purpose of proceeding with the work. The Contractor shall proceed with the fabrication and erection work only after thoroughly satisfying himself in this regard.

4.3 All fabrication and erection drawings shall be issued for construction by the Contractor directly to his work- site. Six copies of such drawings shall simultaneously be submitted to the Engineer-in-Charge who may check/ review some or all such drawings at his sole discretion and offer his comments for incorporation in these drawings by the Contractor.

However, the Contractor shall not proceed with the fabrication of such structures whose fabrication drawings are required to be reviewed before taking up the fabrication work as noted on "Approved for Construction (AFC)" design drawings issued to the Contractor or as conveyed by the Engineer-in-Charge. The fabrication of such structures shall be done only as per the reviewed fabrication drawings.

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The review of such drawings by EIL shall be restricted to the checking of the following only:

i) Structural layout, orientation and elevation of structures/members.

ii) Sizes of members.

iii) Critical joint details.

4.4 Fabrication drawings shall be drawn to scale and shall convey the information clearly and adequately. Following information shall be furnished on such drawings:

i) Reference to design drawing number (along with revision number) based on which fabrication drawing has been prepared.

ii) Structural layout, elevations & sections (with distinct erection marking of all members).

iii) Framing plans, member sizes, orientation and elevations.

iv) Layout and detailing of rain water pipes and gutters showing all necessary levels, connections and provisions wherever required.

v) Detailing of shop/field joints, connections, splices, for required strength and erection.

vi) Location, type, size and dimensions of welds and bolts.

vii) Shapes and sizes of edge preparation for welding.

viii) Details of shop and field joints/welds.

ix) Bill of materials/D.O.D. Lists.

x) Quality of structural steel, plates etc., welding electrodes, bolts, nuts and washers to be used.

xi) Erection assemblies identifying all transportable parts and sub-assemblies with special erection instructions, if required.

xii) Method of erection and special precautions to be taken during erection as required.

xiii) Details of holes and fittings in components necessary for safe lifting and erection purpose.

4.5 The Contractor shall additionally ensure accuracy of the following and shall be solely responsible for the same:

i) Provision for erection and erection clearances.

ii) Marking of members

iii) Cut length of members

iv) Matching of joints and holes.

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v) Provision kept in the members for other interconnected members.

vi) Bill of materials/D.O.D. Lists.

4.6 Connections, splices and other details where not shown on the design drawings shall be suitably designed and shown on the fabrication drawings based on good engineering practice developing full member strength. **Design calculations for such connections/ splices shall be submitted to the Engineer-in-Charge along with the fabrication drawings.**

4.7 Any substitution or change in section shall be allowed only when prior written approval of the Engineer-in-Charge has been obtained. Fabrication drawings shall be updated incorporating all such substitutions/changes by the Contractor at no extra cost to the Owner.

4.8 In case during execution of the work, the Engineer-in-Charge on review of drawings considers any modifications/ substitutions necessary to meet the design parameters/ good engineering practice, these shall be brought to the notice of the Contractor who shall incorporate the same in the drawings and works without any extra cost to the owner. The Contactor will be totally responsible for the correctness of the detailed fabrication drawings and execution of the work.

4.9 Contractor shall incorporate all the revisions made in the design drawings during the course of execution of work in his fabrication drawings, and resubmit the drawings at no extra cost to the Owner. All fabrication shall be carried out only as per the latest AFC design drawings and corresponding fabrication drawings.

4.10 The Contractor shall supply two prints each of the final/as built drawings along with their native soft file to Engineer-in-Charge for reference and record. The rates quoted shall include for the same.

5.0 FABRICATION

5.1 General

5.1.1 Fabrication of structures shall be done strictly as per "Approved for Construction" fabrication drawings (prepared by the Contractor based on the latest design drawings) and in accordance with IS 800, 9595 & other relevant BIS Codes.

5.1.2 Prior to commencement of structural fabrication, undulations in the fabrication yard, if any, shall be removed and area levelled and paved by the Contractor.

5.1.3 Any defective material used in the work shall be replaced by the Contractor at his own expense. Necessary care and precautions shall be taken so as not to cause any damage to the structure during any such removal and replacement.

5.1.4 Any faulty fabrication pointed out at any stage of work by the Engineer-in- Charge, shall be made good or replaced by the Contractor at his own cost.

5.1.5 Tolerances for fabrication of steel structures shall be as per IS 7215.

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5.2 Fabrication Procedure

5.2.1 Straightening & Bending

5.2.1.1 All materials shall be straight and, if necessary, before being worked shall be straightened and/or flattened (unless required to be of curvilinear form) and shall be free from twists.

5.2.1.2 Bending of rolled sections and plates shall be done by cold process to shape/s as shown on drawings.

5.2.1.3 After completion of bending or straightening, welds within the area of bending or straightening shall be thoroughly visually inspected. Nondestructive tests required to be carried out for such locations shall be done only after straightening or bending activity.

5.2.2 Clearances

The erection clearance for cleated ends of members shall be not greater than 2mm at each end. The erection clearance at ends of beams without web cleats and end plates shall be not more than 3mm at each end but where for practical reasons, greater clearance is necessary, suitably designed seatings approved by the Engineer-in-Charge shall be provided.

5.2.3 Cutting

5.2.3.1 Prior to cutting, all members shall be properly marked showing the requisite cut length/width, connection provisions e.g. location and dimensions of holes, welds, cleats etc. Marking for cutting shall be done judiciously so as to avoid wastages or unnecessary joints as far as practicable. Marking shall be done by placing the members on horizontal supports/pads in order to ensure accuracy. Marking accuracy shall be limited to + 1mm.

5.2.3.2 Cutting may be affected by shearing, cropping or sawing. Gas cutting by mechanically controlled torch shall be permitted for mild steel. Hand flame cutting may be permitted subject to the approval of the Engineer-in-Charge.

5.2.3.3 Except where the material is subsequently joined by welding, no loads shall be transmitted into metal through a gas cut surface.

5.2.3.4 Shearing, cropping and gas cutting shall be clean, square, free from any distortion & burrs, and should the Engineer-in-Charge find it necessary, the edges shall be ground afterwards, to make the same straight and uniform at no extra cost to the Owner.

5.2.4 Making Holes

5.2.4.1 Holes for bolts shall not be formed by gas cutting process.

5.2.4.2 Holes through more than one thickness of material of members such as compound stanchions and girder flanges shall, where possible, be drilled after the members are assembled and tightly clamped/bolted together. Punching may be permitted before assembly, provided the thickness of metal is less than 16mm and the holes are punched 3mm less in diameter than the required size and reamed, after assembly, to the full diameter. Punching shall not be adopted for dynamically loaded structures.

5.2.4.3 Holes may be drilled in one operation through two or more separable parts and burrs removed from each part after drilling.

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5.2.4.4 Holes in connecting angles and plates, other than splices, also in roof members and light framing, may be punched full size through material not over 12mm thick, except where required for close tolerance bolts or barrel bolts.

5.2.4.5 All matching holes for black bolts shall register with each other so that a gauge of 2mm less in diameter than the diameter of hole shall pass freely through the assembled members in the direction at right angle to such members. Finished holes shall be not more than 2mm in diameter larger than the diameter of the black bolt passing through them, unless otherwise specified by the Engineer- in-Charge.

5.2.4.6 Holes for turned and fitted bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to H8 tolerance specified in IS 919. Parts to be connected with close tolerance or barrel bolts shall be firmly held together by tacking bolts or clamps and the holes drilled through all the thicknesses in one operation and subsequently reamed to size. Holes not drilled through all the thicknesses in one operation shall be drilled to a smaller size and reamed out after assembly. Where this is not possible, the parts shall be drilled and reamed separately.

5.2.4.7 To facilitate grouting, holes shall be provided in column bases or seating plates exceeding 300mm in width for the escape of air.

5.2.4.8 To avoid accumulation of water in gusseted column bases of laced, battened or box type stanchions, suitable reverse U-type holes shall be provided at the junction of base plate and column section in the vertical gussets for draining out of any water.

5.2.4.9 Slotted holes shall be punched or formed by drilling two holes and completed by cutting.

5.2.5 **Assembly**

The component parts shall be assembled and aligned in such a manner that they are neither twisted nor otherwise damaged, and shall be so prepared that the required camber, if any, is provided. Proper clamps, clips, jigs and other fasteners (bolts and welds) shall be placed in a balanced pattern to avoid any distortion in the members and to ensure their correct positioning (i.e. angles, axes, nodes etc.). Any force fitting, pulling/stretching of members to join them shall be avoided. Proper care shall be taken for welding shrinkage & distortion so as to attain the finished dimensions of the structure shown on the drawings.

5.2.6 **Welding**

5.2.6.1 **General**

a) All joints shall be welded unless noted otherwise on the design drawings.

b) Welding shall be in accordance with IS 816, IS 819, IS 1024, IS 1261, IS 1323 and IS 9595 as appropriate.

c) The Contractor shall make necessary arrangement for providing sufficient number of welding sets of the required capacity, all consumables, cutting and grinding equipment with requisite accessories/ auxiliaries, equipment & materials required for carrying out various tests such as dye penetration, magnetic particle, ultrasonic etc.

d) Adequate protection against rain, dust, snow & strong winds shall be provided to the welding personnel and the structural members during welding operation. In the absence of such a protection no welding shall be carried out.

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e) It shall be the responsibility of the Contractor to ensure that all welding is carried out in accordance with the terms of this specification and relevant BIS codes. The Contractor shall provide all the supervision to fulfil this requirement.

5.2.6.2 **Preparation of Member for Welding**

a) **Edge Preparation**
Edge preparation/bevelling of fusion faces for welding shall be done strictly as per the dimensions shown in the drawings. In case, the same are not indicated, edges shall be prepared (depending on the type of weld indicated in the drawing) as per the details given in IS 9595. Bevelling of fusion faces shall be got checked and approved by the Engineer- in-Charge. The tolerances on limits of gap, root face & included angle shall be as stipulated in IS 9595.

b) **Cleaning**

Welding edges and the adjacent areas of the members (extending upto 20mm) shall be thoroughly cleaned of all oil, grease, scale and rust and made completely dry. Gaps between the members to be welded shall be kept free from all foreign matter.

c) **Preheating**

Preheating of members, shall be carried out as per IS 9595 when the base metal temperature is below the requisite temperature for the welding process being used. Preheating shall be done in such a manner that the parts, on which the weld metal is being deposited, are above the specified minimum temperature for a distance of not less than 75mm on each side of the weld line. The temperature shall be measured on the face opposite to that being heated. However, when there is access to only one face, the heat source shall be removed to allow for temperature equalization (1 minute for each 25mm of plate thickness) before measuring the temperature.

d) **Grinding**

i) Column splices & butt joints of struts and compression members (depending on contact for load transmission) shall be accurately ground and close-butted over the whole section with a tolerance not exceeding 0.2mm locally at any place. In column caps & bases, the ends of shafts together with the attached gussets, angles, channels etc., shall be accurately ground so that the parts connected butt over minimum 90% surface of contact. In case of connecting angles or channels, care shall be taken so that these are fixed with such accuracy that they are not reduced in thickness by grinding by more than 2mm.

ii) Ends of all bearing stiffeners shall be ground to fit tightly at both top and bottom. Similarly bottom of the knife edge supports along with the top surface of column brackets shall be accurately ground to provide effective bearing with a tolerance not exceeding 0.2mm locally at any place.

iii) Slab bases and caps shall be accurately ground over the bearing surfaces and shall have effective contact with the ends of stanchions. Bearing faces which are to be grouted direct to foundations need not be ground if such faces are true & parallel to the upper faces.

iv) Tack welding shall be thoroughly removed by grinding or gouging such that subsequent welding shall be done properly.

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5.2.6.3 **Welding Processes**

Welding of various materials under this specification shall be carried out using one or more of the following processes.

- Manual Metal Arc Welding Process (MMAW)
- Submerge Arc Welding Process (SAW)
- Gas Metal Arc Welding Process (GMAW)
- Flux Cored Arc Welding Process (FCAW)

The welding procedure adopted and consumables used shall be specifically approved by the Engineer-in-Charge. A combination of different welding processes or a combination of electrodes of different classes/makes may be employed for a particular joint only after qualifying the welding procedures to be adopted and obtaining the written approval of the Engineer-in-Charge.

5.2.6.4 **Approval & Testing of Welders**

The Contractor shall satisfy the Engineer-in-Charge that the welders are suitable for the work upon which they will be employed. For this purpose, the welders shall have satisfied the relevant requirements of IS 7318 or AWS D1.1. If the welders will be working to approved welding procedures, they shall have satisfied the relevant requirements of IS 7310 or AWS D1.1.

Adequate means of identification shall be provided to enable each weld to be traced to the welder by whom it was made. The Contractor shall intimate the Engineer-in-Charge sufficiently in advance, the commencement of tests, to enable him to be present to witness the same.

5.2.6.5 **Approval & Testing of Welding Procedures**

The Contractor shall carry out procedure tests in accordance with IS 7307 or AWS D1.1 to demonstrate by means of a specimen weld of adequate length on steel representative of that to be used, that he can make welds with the welding procedure to be used for the work to the complete satisfaction of the Engineer- in-Charge. The test weld shall include weld details from the actual construction and it shall be welded in a manner simulating the most unfavourable instances of fit-up, electrode condition etc., which are anticipated to occur on the particular fabrication. Where material analysis is available, the welding procedure shall be carried out on material with the highest carbon equivalent value.

After welding, but before the relevant tests given in IS 7307 or AWS D1.1 are carried out, the test weld shall be held as long as possible at room temperature, but, in any case not less than 72 hours, and shall then be examined for cracking. The examination procedure shall be sufficiently rigorous to be capable of revealing significant defects in both parent metal and weld metal.

After establishing the welding method, the Contractor shall finally submit to the Engineer-in-Charge for his approval the welding procedure specification in standard format given in IS 9595 before starting the fabrication.

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5.2.6.6 **Sequence of Welding**

a) As far as practicable, all welds shall be made in a sequence that will balance the applied heat of welding while the welding progresses.

b) The direction of the general progression in welding on a member shall be from points where the parts are relatively fixed in position with respect to each other towards points where they have a greater relative freedom of movement.

c) All splices in each component part of a cover-plated beam or built up member shall be made before the component part is welded to other component parts of the member.

d) Joints expected to have significant shrinkage shall be welded before joints expected to have lesser shrinkage.

e) Welding shall be carried continuously to completion with correct number of runs.

f) The Contractor shall choose the welding sequence after carefully studying each case such as to minimize distortion and shrinkage & submit the same to the Engineer-in-Charge for comments and approval.

5.2.6.7 **Welding Technique**

a) After the fusion faces are carefully aligned and set with proper gaps, the root pass of butt joints shall be executed properly so as to achieve full penetration with complete fusion of the root edges.

b) On completion of each run, all slag and spatters shall be removed and the weld and the adjacent base metal shall be cleaned by wire brushing and light chipping. Visible defects such are cracks, cavities and other deposition faults, if any, shall be removed to sound metal before depositing subsequent run of weld.

c) All full penetration butt welds shall be completed by chipping/gouging to sound metal and then depositing a sealing run of weld metal on the back of the joints. Where butt welding is practicable from one side only, suitable backing steel strip shall be used and joint shall be arranged in such a way as to ensure that complete fusion of all the parts is readily obtained.

d) While welding is in progress care shall be taken to avoid any kind of movement of the components, shocks, vibrations to prevent occurrences of weld cracks.

e) Any deviation desired from the recommended welding technique and electrodes shall be adopted only after obtaining written approval of the Engineer-in-Charge.

5.2.6.8 **Inspection & Testing of Welds**

The method of inspection shall be according to IS 822 and extent of inspection and testing shall be in accordance with the relevant applicable standard or, in the absence of such a standard, as specified by the Engineer-in-Charge. Welds shall not be painted or otherwise obscured until they have been inspected, approved and accepted.

The Engineer-in-Charge or his representative shall have access to the Contractor's work at all reasonable times and the Contractor shall provide him with all facilities necessary for

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inspection during all stages of fabrication and erection with, but not limited to, the following objectives.

i) To check the conformity with the relevant standards and suitability of various welding equipments and their performance.

ii) To witness/approve the welding procedure qualification.

iii) To witness/approve the welders performance qualification.

iv) To check whether shop/field welding being executed is in conformity with the relevant specifications and codes of practice.

Inspection and testing of all fabricated structures shall be carried out by the Contractor by any, or, a combination of all the following methods as directed by the Engineer-in-Charge and no separate payment shall be made, unless otherwise mentioned, for inspection and testing of welds/fabricated structures:

A. Visual Inspection

All finished welds (i.e. 100 percent) shall be visually inspected for identification of the following types of weld defects & faults.

a) Weld defects occurring at the surface such as blow holes, exposed porosity, unfused welds etc.

b) Surface cracks in the weld metal or in the parent metal adjacent to it.

c) Damages to the parent metal such as undercuts, burning, overheating etc.

d) Profile defects such as excessive convexity or concavity, overlapping, unequal leg lengths, excessive reinforcement, incompletely filled grooves, excessive penetration beads, root grooves etc.

e) Distortion due to welding i.e., local shrinkage, camber, bowing, twisting, rotation, wariness etc.

f) Linear eccentric, angular and rotational misalignment of parts.

g) Dimensional errors.

B. Mechanical Tests

The mechanical testing (such as tensile load tests, bend tests, impact tests etc.) shall be done in accordance with the relevant standards and as per the instructions of the Engineer-in-Charge.

C. Magnetic Particle/Dye Penetration/Ultrasonic Examination

The examination shall be done at random as directed by the Engineer-in-Charge. Whenever such tests are directed, the tests shall be carried out on joints chosen by him. The tests shall be carried out by employing approved testing procedure in accordance with IS 822.

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D. Radiographic Examination

Radiographic examination shall be carried out only in special cases for random joints as directed by the Engineer-in-Charge. The Contractor shall be paid extra for such examination except for penalty radiographic tests for which the cost shall be borne by him. The Contractor shall make necessary arrangement at his own expense for providing the radiographic equipment, films and all other necessary materials required for carrying out the examination. The tests shall be carried in the presence of the Engineer-in-Charge by employing approved testing procedure in accordance with IS 822. The Contractor shall fulfill all the statutory safety requirements while handling X-ray and Gamma-ray equipment and provide the Engineer- in-Charge all the necessary facilities at site such as dark room, film viewer etc., to enable him to examine the radiographs.

5.2.6.9 **Repair of Faulty Welds**

No repair of defective welds shall be carried out without proper permission of the Engineer-in-Charge and his approval for the corrective procedure.

Welds not complying with the acceptance requirements (as specified by BIS Codes & the Engineer-in-Charge), as revealed during inspection & testing of welds or erection or in-situ condition, shall be corrected either by removing & replacing or as follows:

a)	Excessive convexity	- Reduced to size by removal of excess weld metal.
b)	Shrinkage cracks, cracks in in parent plates and craters	- Defective portions removed down to sound metal and re-welded.
c)	Under cutting.	- Additional weld metal deposited.
d)	Improperly fitted/ misaligned parts.	- Welding cut & edges suitably prepared and parts.
e)	Members distorted by the heat of welding	- Member straightened by mechanical means or careful application of limited amount of heat, temperature of such area not to exceed 650 degree Centigrade (dull red heat).

In removing defective parts of a weld, gouging, chipping, oxygen cutting or grinding shall not extend into the parent metal to any substantial amount beyond the depth of weld penetration, unless cracks or other defects exist in the parent metal. The weld or parent metal shall not be undercut in chipping, grinding, gouging or oxygen cutting.

Any fabricated structure or its component which, in the opinion of Engineer- in-Charge, is defective and/or beyond any corrective action shall be removed forthwith from the site as instructed by the Engineer-in-Charge without any extra claim. The owner reserves the right to recover any compensation due to any loss arising out of such rejections.

5.2.7 **Bolting**

5.2.7.1 All bolts shall be provided such that no part of the threaded portion of the bolts is within the thickness of the parts bolted together. Washers of suitable thickness shall be used under the nuts to avoid any threaded portion of the bolt being within the thickness of parts bolted together.

5.2.7.2 The threaded portion of each bolt shall project through the nut at least one thread.

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5.2.7.3 Flat washers shall be circular and of suitable thickness. However, where bolt heads/nuts bear upon the bevelled surfaces, they shall be provided with square tapered washers of suitable thickness to afford a seating square with the axis of the bolt.

5.2.7.4 Different bolt grades of the same diameter shall not be used in the same structure, except if agreed otherwise by the Engineer-in-Charge.

5.2.7.5 Bearing type bolts shall be used (unless noted otherwise) and tightened firmly by available means.

5.2.8 **Splicing**

5.2.8.1 Splicing of built up/compound/latticed sections shall be done in such a fashion that each component of the section is joined in a staggered manner.

5.2.8.2 Where no butt weld is used for splicing, the meeting ends of two pieces of joist/channel/built up section shall be ground flush for bearing on each other and suitable flange and web splice plates shall be designed and provided for the full strength of the flange/ web of the section and welds designed accordingly.

5.2.8.3 Where full strength butt weld is used for splicing (after proper edge preparation of the web and flange plates) of members fabricated out of joist/ channel/ angles/ built up section, additional flange and web plates shall be provided, over and above the full strength butt welds, to have 40% strength of the flange and web.

5.2.8.4 Where a cover plate is used over a joist/channel section the splicing of the cover plate and channel/joist sections shall be staggered by minimum 500mm. Extra splice plate shall be used for the cover plate and joist/channel section as per clause 5.2.8.2 or 5.2.8.3.

5.2.8.5 Prior approval shall be obtained by the Contractor for locations of splices where not shown on design drawings. For members upto a length of 7m, generally no splice shall be allowed but in exceptional cases one splice shall be allowed at approved location. Maximum two numbers of splices shall be allowed for members exceeding this length.

5.2.9 **Machining & Grinding**

5.2.9.1 All slab bases and slab caps shall be accurately machined over the bearing surfaces and shall be in effective contact with the ends of column sections (shafts).

5.2.9.2 For slab bases and slab caps, ends of column shafts shall be accurately machined. However, for gusseted bases and caps, the column shafts shall be ground flush for effective contact with parts connected together.

5.2.9.3 Gusseted bases and caps shall be ground flush for effective contact with ends of column sections.

5.2.9.4 End of all bearing stiffeners shall be machined or ground to fit tightly at top and bottom without any air gap.

5.2.9.5 While machining or grinding care shall be taken so that the length or thickness of any part does not get reduced by more than 2.0mm.

5.2.9.6 For all machining or grinding works for gusseted base and cap plates, the clearance between the parts joined shall not exceed 0.2mm at any location.

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6.0 MARKING FOR IDENTIFICATION

6.1 Each component shall be distinctly marked (with paint) before delivery in accordance with the marking diagrams and shall bear such other marks as will facilitate erection. Components which are identical in all respects may have the same erection mark.

6.2 For small members which are delivered in bundles or crates, the required marking shall be done on small metal tags securely tied to the bundle.

7.0 SHOP ERECTION

The steel work shall be temporarily shop erected complete or as directed by the Engineer-in-Charge, so that the accuracy of fit may be checked before despatch.

8.0 INSPECTION & TESTING OF STRUCTURES

8.1 The Engineer-in-Charge (or his authorised representative) shall have free access at all times to those parts of the Contractor's works which are concerned with the fabrication of the steel work and shall be provided with all reasonable facilities for satisfying himself that the fabrication is being undertaken in accordance with the provisions of these specifications & other relevant BIS Codes.

8.2 Should any structure or part of a structure be found not to comply with any of the provisions of this specification (or relevant BIS Codes as referred to), it shall be liable to rejection. No structure or part of the structure, once rejected shall be resubmitted for inspection, exception cases where the Engineer-in-Charge or his authorised representative considers the defect as rectifiable.

8.3 Defects which may appear during/after fabrication/ erection shall be made good only with the consent of the Engineer-in-Charge and procedure laid down by him.

8.4 All necessary gauges and templates shall be supplied free to the Engineer-in-Charge by the Contractor whenever asked for during inspection. The Engineer-in- Charge, may at his discretion, check the test results obtained at the Contractor's works by independent tests at a test house, and the cost of such tests shall be borne by the Contractor.

9.0 SHOP PAINTING

9.1 All components and members of steel work shall be given one shop coat of primer, as specified in the tender, immediately after the surfaces have been properly prepared (i.e. degreased, derusted, descaled & cleaned) in accordance with the job specification or 6-79-0020, as applicable.

The primer coat shall be applied over completely dry surfaces (using brushes of good quality) in a manner so as to ensure a continuous and uniform film without "holidaying". Special care shall be taken to cover all the crevices, corners, edges etc. However, in areas which are difficult to reach by brushing, daubers/mops shall be used by dipping the same in paint and then pulling/ pushing them through the narrow spaces. The primer coat shall be air dried and shall have the thickness as per EIL Specification no. 6-79-0020 or the relevant job specification.

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9.2 Surfaces which are inaccessible after shop assembly, shall receive the full specified protective treatment before assembly (this shall not apply to the interior of sealed hollow sections).

9.3 Steel surfaces shall not be painted within a suitable distance of any edges to be welded if the paint specified would be harmful to welders or impair the quality of the welds.

9.4 Welds and adjacent parent metal shall not be painted prior to deslagging, inspection and approval by the Engineer-in-Charge.

9.5 Parts to be encased in concrete shall have only one coat of primer and shall not be painted after erection.

10.0 PACKING

10.1 All items shall be suitably packed in case these are to be despatched from the fabrication shop to the actual site of erection so as to protect them from any damage/distortion or falling during transit. Where necessary, slender projecting parts shall be temporarily braced to avoid warping during transportation.

10.2 Small parts such as gussets, cleats etc., shall be securely wired on to their respective main members.

10.3 Bolts, nuts washers etc. shall be packed in crates.

11.0 TRANSPORTATION

Loading and transportation shall be done in compliance with transportation rules. In case, certain parts can not be transported in the lengths stipulated on the drawings, the position details of such additional splice joints shall be got approved by the Engineer-in- Charge.

12.0 SITE (FIELD) ERECTION

12.1 Plant & Equipment

The suitability and capacity of all plant and equipment used shall be to the complete satisfaction of the Engineer-in-Charge.

12.2 Storing & Handling

All steel work shall be so stored and handled at site so that the members are not subjected to surface abrasion, excessive stresses and any damage.

12.3 Setting Out

Prior to setting out of the steel work, the Contractor shall get himself satisfied about the correctness of levels, alignment, location of existing concrete pedestals/columns/brackets and holding down bolts/pockets provided therein. Any minor modification in the same including chipping, cutting and making good, adjusting the anchor bolts etc., if necessary, shall be carried out by the Contractor at his own expense. The positioning and levelling of all steel work including plumbing of columns and placing of every part of the structure with

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accuracy shall be in accordance with the drawings and to the complete satisfaction of the Engineer-in-Charge.

12.4 Tolerances

Tolerances for erection of steel structures shall be as per Annexure 'A'

13.0 SAFETY & SECURITY DURING ERECTION

13.1 The contractor shall comply with IS 7205 for necessary safety and adhere to safe erection practices and guard against hazardous as well as unsafe working conditions during all stages of erection.

13.2 During erection, the steel work shall be securely bolted or otherwise fastened and when necessary, temporarily braced/guyed to provide for all loads to be carried by the structure during erection till the completion, including those due to the wind, erection equipment & its operation etc. at no extra cost to the owner. For the purpose of guying, the Contractor shall not use other structure in the vicinity without prior written permission of the Engineer-in-Charge.

13.3 No permanent bolting or welding shall be done until proper alignment has been achieved.

13.4 Proper access, platform and safety arrangement shall be provided for working and inspection, (at no extra cost to the owner) whenever required.

14.0 FIELD CONNECTIONS

14.1 Field Bolting

Field bolting shall be carried out with the same care as required for shop bolting.

14.2 Field Welding

All field assembly and welding shall be executed in accordance with the requirements for shop assembly and welding. Holes for all erection bolts - where removed after final erection shall be plugged by welding. Alternatively, erection bolts may be left and secured.

15.0 GROUTING

15.1 Prior to positioning of structural columns/girders/ trusses over the concrete pedestals/columns/brackets, all laitance & loose material shall be removed by wire brushing & chipping. The bearing concrete surfaces shall be sufficiently levelled, hacked with flat chisels to make them rough, cleaned (using compressed air) and made thoroughly wet. All pockets for anchor bolts shall also be similarly cleaned and any excess water removed. Thereafter, the structural member shall be erected, aligned & plumbed maintaining the base plates/shoe plates at the levels shown in the drawings, with necessary shims/pack plates/wedges.

15.2 After final alignment and plumbing of the structure, the forms shall be constructed alround and joints made tight to prevent leakage. Grouting (under the base plates/shoe plates including grouting of sleeves & pockets) shall be done with non-shrink grout having compressive strength (28 days) not less than 40N/sq.mm. Non shrink grout shall be of free

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flow premix type and of approved quality and make. It shall be mixed with water in proportion as specified by the manufacturer. Ordinary 1:2 cement/sand mortar grout shall be used only for small, isolated structures e.g. operating platforms not supporting any equipment, pipe supports, crossovers, stairs & ladders. The thickness of grout shall be as shown on the drawings. In case, not mentioned grout thickness shall not be less than 25mm nor more than 50mm in any case.

15.3 The grout mixture shall be poured continuously (without any interruption till completion) by grouting pumps from one side of the base plate and spread uniformly with flexible steel strips and rammed with rods, till the space is filled solidly and the grout mixture carried to the other side of the base plate.

15.4 The grout mixture shall be allowed to harden for a period as decided by the Engineer-in-Charge. At the end of this period, the shims/wedges/pack plates may be removed and anchor bolts tightened uniformly. The alignment of the structure shall now be rechecked and if found correct, the voids left by the removal of shims/wedges/pack plates (if removed) must be filled up with a similar mixture of grout. In case after checking, serious misalignment is indicated, the grout shall be removed completely and fresh grouting done after making appropriate correction of alignment.

16.0 SCHEME AND SEQUENCE OF ERECTION

The Contractor shall furnish the detailed scheme and sequence of erection to match with the project schedule and get the same approved by the Engineer-in- Charge. All necessary co-ordination and synchronization shall be done with the Civil contractor where Civil works are not included in the scope of structural contractor at no extra cost so as to match with the project schedule.

17.0 PAYMENT

This clause shall apply to Item Rate tender only.

17.1 Payment for structural steel works shall be made on the basis of admissible weight in metric tons (determined as described in clause 17.2 and 17.3) of the structure accepted by the Engineer-in-Charge. The rate shall include supplying (as per supply conditions given in the Tender) fabricating, erecting in position (at all levels & locations), testing/examining (excluding radiography only) of bolted and/or welded structural steel works of all types (including all built up/compound sections made out of rolled sections and/or plates) including all handling, transporting, storing, straightening if required, cutting, edge preparation, preheating, bolting and welding of joints (including sealing the joints of box sections with continuous welding), finishing edges by grinding/machining as shown, fixing in line & level with temporary staging & bracing and removal of the same after erection, grouting with non-shrink/ordinary grout as specified, preparation of fabrication & erection drawings, & erection schedule and getting them reviewed, preparation and submission of as built drawings, preparing the surfaces for painting, and applying the primer as specified after fabrication, return of surplus materials to owner's stores and material reconciliation in the case of materials supplied by the owner as per relevant contract conditions etc. all complete for all the operations mentioned in the foregoing clauses.

17.2 The weight for payment shall be determined from the fabrication drawings and respective bill of materials prepared by the Contractor. The bill of materials shall be checked and approved by the Engineer-in-Charge before making the payment. The Contractor shall prepare full scale template in order to supplement/verify the actual cutting dimensions

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where so directed by the Engineer-in-Charge. The weight shall be calculated on the basis of BIS Hand Book wherever applicable. In case sections used are different from BIS sections, then Manufacturers' Hand Book shall be adopted. No allowance in weight shall be made for rolling tolerances.

17.3 Welds, bolts, nuts, washers, shims, pack plates, wedges, grout and shop painting shall not be separately measured. The quoted rate shall be deemed to include the same.

17.4 The rate shall include all expenses related to safety & security arrangements during erection and all plants & tools required for fabrication, transportation & erection.

18.0 PAINTING AFTER ERECTION

18.1 General

18.1.1 The scope of painting after erection shall be at the sole discretion of the Engineer-in-Charge and the Contractor shall obtain written instruction in this regard sufficiently prior to taking up any procurement of paint and execution of painting work after erection of steel structures.

18.1.2 The Contractor shall carry out the painting work in all respects with the best quality of approved materials (conforming to relevant EIL Specification no. 6-79-0020 or the job specification, as applicable) and workmanship in accordance with the best engineering practice. The Contractor shall furnish characteristics of paints (to be used) indicating the suitability for the required service conditions. The paint manufacturer's instructions supplemented by Engineer-in-Charge's direction, if any, shall be followed at all times. Particular attention shall be paid to the following:

- Proper storage to avoid exposure & extremes of temperature.
- surface preparation prior to painting.
- Mixing & thinning.
- Application of paint and the recommended limit on time intervals between consecutive coats.

18.1.3 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.

18.1.4 Surface which shall be inaccessible after site assembly shall receive the full specified protective treatment before assembly.

18.1.5 Primers & finish coat paints shall be from the same manufacturer in order to ensure compatibility. Painting colour code shall be as per Annexure-'B' or the job specification.

18.2 Rub Down & Primer Application

The shop coated surfaces shall be rubbed down thoroughly with emery/abrasive paper to remove dust, rust, other foreign matters and degreased, if required, in accordance with EIL specification no. 6-79-0020 or the job specification, as applicable, cleaned with warm fresh water and air dried. The portions, from where the shop coat has peeled off, shall be touched up and allowed to dry.

Primer coat as per EIL specification no. 6-79-0029 or the job specification, as applicable, shall be applied by brushing/ spraying over the shop coat in a manner so as to ensure a continuous and uniform film throughout. Special care shall be taken to cover all the crevices, corners, edges etc. The final primer coat shall be air dried and shall have a

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minimum film thickness as per EIL Specification no. 6-79-0020 or job specification after drying, as applicable.

In case different cleaning procedure & primer specifications are specified in the drawing/Tender, the same shall be adopted.

18.3 Final Paint Application

After the primer is hard dry, the surfaces shall be dusted off and the paint as per EIL specification no. 6-79-0020 or the job specification, as specified, shall be applied by brushing/spraying so that a film free from "holidaying" is obtained. The colour & shade of first coat of paint shall be slightly lighter than the second coat in order to identify the application of each coat. The second coat of paint shall be applied after the first coat is hard dry. The minimum thickness of each film shall be 20 microns (± 10% tolerance) after drying.

In case a different type of paint & painting procedure are specified in the drawing/tender, the same shall be adopted.

18.4 Inspection & Testing of Painting Works

18.4.1 All painting materials including primers & thinners brought to site by the Contractor for application shall be procured directly from reputed and approved manufacturers and shall be accompanied by manufacturer's test certificates. Paint formulations without certificates shall not be accepted.

18.4.2 The Engineer-in-Charge at his discretion may call for additional tests for paint formulations. The Contractor shall arrange to have such tests performance including batch wise test of wet paints for physical & chemical analysis. All costs shall be borne by the Contractor.

18.4.3 The painting work shall be subject to inspection by the Engineer-in-Charge at all times. In particular, the stage inspection will be performed and Contractor shall offer the work for inspection and approval at every stage before proceeding with the next stage. The record of inspection shall be maintained. Stages of inspection are as follows:

(a) Surface preparation
(b) Primer application
(c) Each coat of paint

18.4.4 Any defect noticed during the various stages of inspection shall be rectified by the Contractor to the entire satisfaction of the Engineer-in-Charge before proceeding further. Irrespective of the inspection, repair and approval at intermediate stages of work the Contractor shall be responsible for making good any defects found during final inspection/guarantee period/defect liability period, as defined in General Conditions of Contract. Dry film thickness (DFT) shall be checked and recorded after application of each coat. The thickness shall be measured at as many locations as decided by the Engineer-in-Charge. The Contractor shall provide standard thickness measuring instrument such as elkometer (with appropriate range for measuring dry film thickness of each coat) free of cost to the Engineer-in-Charge whenever asked for.

18.5 Payment

Payment for painting of structural steel works shall be made on the basis of admissible weight in metric tons of the painted structures accepted by the Engineer-in-Charge.

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The rate shall include supplying & applying the paint, specified in the tender, of approved quality and shade over the primer, specified in the tender, over the shop primer already applied to structural steel works of all types/shapes at all levels, locations & positions including storage, surface preparation, degreasing, cleaning, drying, touching up of shop primer coat, providing temporary staging, testing etc. all complete to the entire satisfaction of the Engineer-in-Charge.

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ANNEXURE-'A'
(Clause 12.4)

Maximum Permissible Erection Tolerances

A.	**Columns**	
1.	Deviation of column axes at foundation top level with respect to true axes.	
	i) In longitudinal direction	± 5 mm
	ii) In lateral direction	± 5 mm
2.	Deviation in the level of bearing surface of columns at foundation top with respect to true level	± 5 mm
3.	Out of plumb (Verticality) of column axis from true vertical axis, as measured at top:	
	i) Upto and including 30m height whichever is less.	± H/1000 or ± 25 mm
	ii) Over 30m height	± H/1200 or ± 35 mm whichever is less.
4.	Deviation in straightness in longitudinal & transverse planes of column at any point along the height.	± H/1000 or ± 10 mm whichever is less.
5.	Difference in the erected positions of adjacent pairs of columns along length or across width of building prior to connecting trusses/beams with respect to true distance.	± 5 mm
6.	Deviation in any bearing or seating level with respect to true level.	± 5 mm
7.	Deviation in difference in bearing levels of a member on adjacent pair of columns both across & along the building.	+ 5 mm

Note: 1. Tolerance specified under 3 should be read in conjunction with 4 & 5.
Note: 2. 'H' is the column height in mm.

B.	**Trusses**	
1.	Shift at the centre of span of top chord member with respect to the vertical plane passing through the centre of bottom chord.	± 1/250 of height of truss in mm at centre of span or ± 15mm whichever is less.
2.	Lateral shift of top chord of truss at the centre of span from the vertical plane passing through the centre of supports of the truss.	± 1/1500 of span of truss in mm or ± 10mm Whichever is less.
3.	Lateral shift in location of truss from its true position.	± 10mm

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4.	Lateral shift in location of purlin from true position.	± 5mm
5.	Deviation in difference of bearing levels of truss from the true level.	± 1/1200 of span of truss in mm or 20mm whichever is less.

C. Gantry Girders & Rails

1.	Shift in the centre line of crane rail with respect to centre line of web of gantry girder.	$\pm [\{\frac{\text{web thickness (mm)}}{2}\}+2 \text{ mm}]$
2.	Shift of alignment of crane rail (in plan) with respect to true axis of crane rail at any point.	± 5 mm
3.	Deviation in crane track gauge with respect to true gauge.	
	i) For track gauge upto and including 15 m.	± 5 mm.
	ii) For track gauge more than 15m. Subject to maximum ± 10mm, where S in metres is true gauge.	± [5 + 0.25 (S-15)]
4.	Deviation in the crane rail level at any point from true level.	± 10 mm.
5.	Difference in level between crane track rails (across the bay) at	
	i) Supports of gantry girders	15 mm.
	ii) Mid span of gantry girders	20 mm.
6.	Relative shift of crane rail surfaces (at a joining) in plan and elevation.	2 mm.

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ANNEXURE-'B'
(Clause 18.1)

PAINTING COLOUR CODE FOR STRUCTURAL STEEL

1.	GANTRY GIRDER & MONORAIL	DARK GREEN
2.	GANTRY GIRDER & MONORAIL STOPPER SIGNAL	RED
3.	BUILDING STRUCTURAL STEEL COLUMNS, BRACKETS, BEAMS, BRACINGS, ROOF TRUSS, PURLINS, SIDEGIRTS, LOUVERS, STRINGERS	DARK ADMIRALITY GREY
4.	PIPE RACK STRUCTURE & TRESTLE	DARK ADMIRALITY GREY
5.	CHEQUERED PLATE (BOTH FACES)	BLACK
6.	GRATING	BLACK
7.	LADDER RUNGS	BLACK VERTICALS & CAGE RED
8.	HAND RAILING	
	- HANDRAIL, MIDDLE RAIL, TOE PLATE	SIGNAL RED
	- VERTICAL POST	BLACK

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मानक विनिर्देशन
सिविल एवं संरचनात्मक कार्य

STANDARD SPECIFICATION
CIVIL & STRUCTURAL WORKS

संरचनात्मक इस्पात कार्य
(ट्यूबुलर/खोखले काट)

STRUCTURAL STEEL WORKS
(TUBULAR/HOLLOW SECTIONS)

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
8	13.05.25	UPDATED & REISSUED	RIYA	VIKRAM	AS	M. NANDI
7	24.01.20	UPDATED & REISSUED	TK	AJS	RS	RK TRIVEDI
6	21.08.14	UPDATED & REISSUED	PM	AS	PKM	S.CHANDA
5	29.01.10	REAFFIRMED & ISSUED	AS	PKM	SCH	N. DUARI
4	18.04.00	UPDATED & REISSUED	DPN	RS	SCJ	MI

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Abbreviations:

BIS	:	Bureau of Indian Standards
IS	:	Indian Standards

Structural Standards Committee

Convenor: Mr. Anurag Sinha

Members:
Mr. Virender Goel
Mr. Deepak Agrawal
Ms. Alpana Srivastava
Dr. Sudip Paul
Mr. Charanjeet Singh (Projects)
Mr. Indrajit Neog (Construction)
Ms. Papia Mandal
Mr. Vikram Kumar Gupta

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CONTENTS

1.0 SCOPE 4
2.0 REFERENCES 4
3.0 MATERIAL 4
4.0 FABRICATION DRAWINGS 5
5.0 FABRICATION 7
6.0 MARKING FOR IDENTIFICATION 8
7.0 SHOP ERECTION 8
8.0 INSPECTION AND TESTING 9
9.0 SHOP PAINTING, PACKING AND TRANSPORTATION 9
10.0 SITE (FIELD) ERECTION 9
11.0 SAFETY AND SECURITY DURING ERECTION 10
12.0 FIELD CONNECTIONS 10
13.0 GROUTING 10
14.0 SCHEME AND SEQUENCE OF ERECTION 11
15.0 PAINTING AFTER ERECTION 11
16.0 PAYMENT 11
17.0 PAYMENT 12
ANNEXURE-'A' 13
ANNEXURE-'B' 15

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1.0 SCOPE

This specification covers the requirements for design (Refer Annexure 'A'), material, fabrication, modification, assembly, tests/ examinations, transportation, erection and painting preparation of fabrication drawings of bolted and/or welded structural steel works using tubular/ hollow sections for general construction work.

2.0 REFERENCES

2.1.1 BIS Codes

IS 800, IS 806, IS 816, IS 1161, IS 4923, IS 7205, IS 7215, IS 9595 & other relevant Codes.

2.1.2 International Standard

AWS D1.1 Structural Welding Code - Steel

2.2 EIL Specifications

6-68-0002 : Materials
6-68-0006 : Structural Steel Works
6-79-0020 : Standard specification for surface preparation and protective coating

2.3 In case of conflict between the clauses mentioned in this specification and those in the Indian Standards, this specification shall govern. Any special provision as shown or noted on the design drawings shall govern over the provisions of this specification.

3.0 MATERIAL

3.1 General

All materials shall conform to their respective specifications given in EIL Specification no. 6-68-0002. The use of equivalent or alternative materials shall be permitted only in very special cases and for all such cases prior written approval of the Engineer-in-Charge shall be obtained.

3.2 Receipt and Storing of Materials

3.2.1 Each section shall be marked for identification and each lot shall be accompanied by manufacturer's quality certificate, chemical analysis and mechanical characteristics.

3.2.2 All sections shall be checked, sorted out and arranged by grade and quality in the store. Any instruction given by the Engineer-in-Charge in this respect shall be strictly followed.

3.2.3 All material shall be free from surface defects such as pitting, cracks, laminations, twists etc. Defective material shall not be used and all such rejected material shall be immediately removed from the store/site. The decision of Engineer-in-Charge in this regard shall be final and binding.

3.2.4 Welding wires and electrodes (packed in their original cartons) shall be stored separately by quality and lots inside a dry and enclosed room in compliance with IS 9595 and as per instructions given by the Engineer-in-Charge. Electrodes shall be kept perfectly dry to ensure satisfactory operation and weld metal soundness.

3.2.5 Each lot of electrodes, bolts, nuts etc. shall be accompanied by manufacturer's quality test certificates.

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3.2.6 All bolts (including nuts and washers) shall be checked, sorted out and arranged diameter-wise by grade and quality in the store.

3.3 Material Tests

3.3.1 The Contractor shall submit manufacturer's quality certificates for all the materials supplied by him. In case quality certificates are not available or are incomplete or when material quality differs from standard specifications, such materials shall not be used in the construction. However, the Contractor shall get all appropriate tests conducted in approved test houses for such materials as directed by the Engineer-in-Charge, at no extra cost to the owner and submit the same to the Engineer-in-Charge for his approval. The Engineer-in-Charge may approve the use of such materials entirely at his discretion.

3.3.2 The Contractor shall ensure that all material brought to site are duly approved by the Engineer-in-Charge. Rejected materials shall not be used and shall be removed from site forthwith. Any material of doubtful quality for which specific tests are to be carried out as per the instruction of the Engineer- in-Charge shall be separately stacked and properly identified.

4.0 FABRICATION DRAWINGS

4.1 Fabrication and erection drawings shall be prepared by the Contractor on the basis of "Approved for Construction" (AFC) design drawings, EIL Standards issued to the Contractor. These drawings shall be prepared by Contractor or by an agency engaged by the contractor using TEKLA or AUTODESK Advance Steel or equivalent 3D Modeling software and approved by the Engineer-in-Charge.

4.2 Fabrication and erection drawings shall be thoroughly checked, stamped "Approved for Construction" and signed by the Contractor's own responsible Engineer irrespective of the fact that such drawings are prepared by the Contractor or his approved agency, to ensure accuracy and correctness of the drawings. Unchecked and unsigned drawings shall not be used for the purpose of proceeding with the work. The Contractor shall proceed with the fabrication and erection work only after thoroughly satisfying himself in this regard.

4.3 All fabrication and erection drawings shall be issued for construction by the Contractor directly to his work site. Six copies of such drawings shall simultaneously be submitted to the Engineer-in-Charge who may check/ review some or all such drawings at his sole discretion and offer his comments for incorporation in these drawings by the Contractor.

However the contractor shall not proceed with the fabrication of such structures whose fabrication drawings are required to be reviewed before taking up the fabrication work as noted on "Approved for Construction" (AFC) design drawings issued to the contractor or as conveyed by the Engineer-in-Charge. The fabrication of such structures shall be done only as per the reviewed fabrication drawings.

The review of such drawings by EIL shall be restricted to the following only:

a) Structural layout, orientation and elevation of structures/ members.

b) Sizes of members

c) Critical joint details

4.4 Fabrication drawings shall be drawn to scale and shall convey the information clearly and adequately. Following information shall be furnished on such drawings.

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a) Reference to design drawing number (along with revision number, if any) based on which fabrication drawing has been prepared.

b) Structural layout, elevations & sections (with distinct erection marking of all members).

c) Framing plans, member sizes, orientation and elevations.

d) Layout and detailing of rain water pipes and gutters showing all necessary levels, connections and provisions wherever required.

e) Detailing of shop/field joints/welds, connections, splices, for required strength and erection.

f) Location, type, size and dimensions of welds and bolts.

g) Shapes and sizes of edge preparation for welding.

h) Details of shop and field joints/welds.

i) Bill of materials.

j) Quality of structural steel tubes, hollow sections, plates etc., welding electrodes, bolts, nuts and washers to be used.

k) Erection assemblies identifying all transportable parts and sub-assemblies with special erection instructions, if required.

l) Method of erection and special precautions to be taken during erection as required.

m) Details of holes and fittings in components necessary for safe lifting and erection purpose.

4.5 The Contractor shall additionally ensure accuracy of the following and shall be solely responsible for the same:

a) Provision for erection and erection clearances.

b) Marking of members.

c) Cut length of members.

d) Matching of joints and holes.

e) Provision kept in the members for other interconnected members.

f) Bill of materials.

4.6 Connections, splices and other details where not shown on the design drawings shall be suitably designed and shown on the fabrication drawings based on good engineering practice developing full member strength. **Design calculations for such connections/ splices shall be submitted to the Engineer-in-Charge along with the fabrication drawings.**

4.7 Any substitution or change in section shall be allowed only when prior written approval of the Engineer-in-Charge has been obtained. Fabrication drawings shall be updated incorporating all such substitutions/changes by the Contractor at no extra cost to the owner.

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4.8 In case during execution of the work, the Engineer-in-Charge on review of drawings considers any modifications/substitutions necessary to meet the design parameters/ good engineering practice, these shall be brought to the notice of the Contractor who shall incorporate the same in the drawings without any extra cost to the owner. The Contractor will be totally responsible for the correctness of the detailed fabrication drawings and execution of the work.

4.9 Contractor shall incorporate all the revisions made in the design drawings during the course of execution of work in his fabrication drawings, and resubmit the drawings at no extra cost to the owner. All fabrication shall be carried out only as per the latest AFC design drawings and corresponding fabrication drawings.

4.10 The Contractor shall supply two prints each of the final/as-built drawings along with their native soft files to Engineer-in-Charge for reference and record. The rates quoted shall include for the same.

5.0 FABRICATION

5.1 General

5.1.1 Fabrication of structures using tubular/hollow sections shall be done strictly as per "Approved For Construction" fabrication drawings (prepared by the Contractor based on the latest design drawings) and in accordance with IS 800, IS 806, IS 1161, IS 4923, IS 9595 and other relevant BIS Codes.

5.1.2 Prior to commencement of fabrication, undulations in the fabrication yard, if any, shall be removed and area levelled and paved by the Contractor.

5.1.3 Any defective material used in the work shall be replaced by the Contractor at his own expense. Necessary care and precautions shall be taken so as not to cause any damage to the structure during any such removal and replacement.

5.1.4 The components of the structure shall be assembled in such a manner that they are neither twisted nor otherwise damaged and be so prepared that the specified cambers, if any, are maintained.

5.1.5 Any faulty fabrication pointed out at any stage of work by the Engineer-in- Charge, shall be made good or replaced by the Contractor at his own cost.

5.1.6 Tolerances for fabrication of steel work shall conform to IS 7215.

5.2 Straightening & Bending

5.2.1 All materials before being assembled shall be straightened, if necessary (unless required to be of a curvilinear form) and shall be free from twist. Tubes shall not deviate from straightness by more than 1/600 of any length.

5.2.2 Bending of structural hollow or tubular sections shall be done by cold process to shapes as shown on drawings.

5.3 Cut Edges

Edges shall be dressed to a neat and workman like finish and be free from distortion.

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5.4 Caps and Bases for Columns

The ends of all tubes and hollow sections for columns (transmitting loads through the ends) shall be ground flush and made true square to the axis of the member and shall be provided with caps and base plates as shown on the drawings.

5.5 Sealing of Tubes and Hollow Sections

When the end of member is not automatically sealed by virtue of its connection by welding to another member, the end shall be properly and completely sealed against ingress of moisture. Before sealing, the inside of the tubes and hollow sections shall be made dry.

5.6 Flattened Ends

In tubular construction, joints may be formed by flattening or splitting or otherwise formed shapes for welded or bolted connections. The change in section shall be gradual to avoid concentration of stresses and all flattening shall be done by cold process only.

5.7 Welding

Welding shall be strictly in accordance with IS 9595 and carried out by experienced welders only. For welding (including testing & examining of welds) relevant clauses of EIL Specification no. 6-68-0006 for Structural Steel Works shall be referred to the extent applicable.

5.8 Bolting

5.8.1 Washers shall be specially shaped where necessary to give the nuts and the heads of bolts a full bearing.

5.8.2 In all cases where the full bearing area of the bolt is to be developed, the threaded portion of the bolt shall not be within the thickness of parts bolted together, and washer(s) of appropriate thickness shall be provided to allow the nut to be completely tightened.

5.8.3 The threaded portion of each bolt shall project through the nut at least one thread.

5.8.4 Different bolt grades of the same diameter shall not be used in the same structure, except if agreed otherwise by the Engineer-in-Charge.

5.8.5 Bearing type bolts shall be used (unless noted otherwise) and tightened firmly by available means.

6.0 MARKING FOR IDENTIFICATION

Each component shall be distinctly marked before delivery, in accordance with the marking diagram and shall bear such other marks as will facilitate erection.

7.0 SHOP ERECTION

The steel work shall be temporarily shop erected complete or as directed so that accuracy of fit may be checked before dispatch.

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8.0 INSPECTION AND TESTING

8.1 The Engineer-in-Charge (or his authorised representative) shall have free access at all times to those parts of the Contractor's Works which are concerned with the storing and fabrication of the steel work and shall be provided with all reasonable facilities for satisfying himself that fabrication is being undertaken in accordance with the provisions of these specifications and other relevant BIS Codes.

8.2 Should any structure or part of a structure be found not to comply with any of the provisions of these specifications and other relevant BIS Codes, it shall be rejected. No structure or part of the structure, once rejected shall be resubmitted for inspection, except in cases where the Engineer-in-Charge or his authorised representative considers the defect as rectifiable.

8.3 Defects which may appear during fabrication/erection shall be made good only with the consent of the Engineer-in-Charge and procedure laid down by him.

8.4 All necessary gauges and templates shall be supplied free to the Engineer-in- Charge by the Contractor whenever asked for during inspection. The Engineer- in-Charge may, at his discretion, check the test results obtained at the Contractor's works by independent tests at a test house, the cost of such tests shall be borne by the Contractor.

9.0 SHOP PAINTING, PACKING AND TRANSPORTATION

9.1 All components and members of steel work shall be given one shop coat of primer as specified in the tender, immediately after the surface have been properly prepared (i.e. degreased, derusted, descaled and cleaned) in accordance with EIL Specification No. 6-79-0020 or the job specification, as applicable.

9.2 All items shall be suitably packed in case they are to be dispatched from the fabrication shop to the actual site of erection so as to protect them from any damage or distortion during transit.

10.0 SITE (FIELD) ERECTION

10.1 Plant and Equipment

The suitability and capacity of all plant and equipment used shall be to the complete satisfaction of the Engineer-in-Charge.

10.2 Storing and Handling

All steel work shall be so stored and handled at site so that the members are not subjected to excessive stresses and any damage.

10.3 Setting out

Prior to setting out of the steel work, the Contractor shall get himself satisfied about the correctness of levels, alignment, location of existing pedestals/ columns and holding down bolts/ pockets provided therein. Any minor modification in the same including chipping, cutting and making good, adjusting the anchor bolts etc. if necessary, shall be carried out by the Contractor at his own expense. The positioning and levelling of all steel work including plumbing of columns and placing of every part of the structure with accuracy shall be in accordance with the drawings and to the complete satisfaction of the Engineer-in-Charge.

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10.4 Tolerances

Tolerances for erection of steel structures shall be as per Annexure - 'B'.

11.0 SAFETY AND SECURITY DURING ERECTION

11.1 The Contractor shall comply with IS 7205 for necessary safety and adhere to safe erection practices and guard against hazardous and unsafe working conditions during all stages of erection.

11.2 During erection, the steel work shall be securely bolted or otherwise fastened, and when necessary, temporarily braced to provide for all loads to be carried by the structure during erection till the completion including those due to wind, erection equipment and its operation etc. For the purpose of guying the Contractor shall not use other structures in the vicinity without prior written permission of the Engineer-in-Charge.

11.3 No permanent bolting or welding shall be done until proper alignment has been achieved.

11.4 Proper access, platform and safety arrangement shall be provided for working and inspection at no extra cost whenever required.

12.0 FIELD CONNECTIONS

12.1 Field Bolting

12.1.1 Field bolting shall be carried out with the same care as required for shop bolting.

12.2 Field Welding

12.2.1 All field assembly and welding shall be executed in accordance with the requirements for shop. Holes for all erection bolts where removed after final erection shall be plugged by welding. Alternatively erection bolts may be left and secured. Proper access, platform and safety arrangements shall be provided for inspection whenever required.

13.0 GROUTING

13.1 Prior to positioning of structural columns/ girders/ trusses over the concrete pedestals/ columns/ brackets, all laitance & loose material shall be removed by wire brushing & chipping. The bearing concrete surfaces shall be sufficiently leveled, hacked with flat chisels to make them rough, cleaned (using compressed air) and make thoroughly wet. All pockets for anchor bolts shall be thoroughly cleaned and excess water, if any, shall be removed. Thereafter, the structural members shall be erected, aligned & plumbed maintaining the base plates/ shoe plates at the levels shown in the drawings, with necessary shims/ pack plates/ wedges.

13.2 After final alignment and plumbing of the structure, the forms shall be constructed alround and joints made tight to prevent leakage. Grouting (under the base plates/ shoe plates including grouting of sleeves & pockets) shall be done with non-shrink grout having compressive strength (28 days) not less than 40 N/sq.mm. Non shrink grout shall be of free flow premix type of approved quality and make and mixed with water in proportion as specified by the manufacturer. Ordinary 1:2 cement/ sand mortar grout shall be used only for small, isolated structures e.g. operating platforms not supporting any equipment, pipe supports, cross overs, stairs & ladders. The thickness of grout shall be as shown on the

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drawings. In case, not mentioned grout thickness shall not be less than 25mm nor more than 50mm in any case.

13.3 The grout mixture shall be poured continuously (without any interruption till completion) by grouting pumps from one side of the base plate and spread uniformly with flexible steel strips and rammed with rods, till the space is filled solidly and the grout mixture carried to the other side of the base plate.

13.4 The grout mixture shall be allowed to harden for a period as decided by the Engineer-in-Charge. At the end of this period, the shims/ wedges/ pack plates may be removed and anchor bolts tightened uniformly. The alignment of the structure shall now be rechecked and if found correct, the voids left by the removal of shims/ wedges/pack plates (if removed) must be filled up with a similar mixture of grout. In case after checking, serious misalignment is indicated, the grout shall be removed completely and fresh grouting done after making appropriate correction of alignment.

14.0 SCHEME AND SEQUENCE OF ERECTION

The Contractor shall furnish the detailed scheme and sequence of erection to match with the project schedule and get the same approved by the Engineer-in-Charge. All necessary co-ordination and synchronization shall be done with the civil contractor where civil works are not included in the scope of structural contractor at no extra cost so as to match with the project schedule.

15.0 PAINTING AFTER ERECTION

Painting of Structural Steel Works using (tubular/ hollow sections) shall be done in accordance with relevant clauses of EIL Specification no. 6-68-0006.

16.0 PAYMENT

(Where design and design drawings are excluded from the scope of the Contractor)

16.1 Payment for structural steel works fabricated and made out of tubular/ hollow sections shall be made on the basis of admissible weight in metric tons (determined as described in clause 16.2 to 16.3) of the structure accepted by the Engineer-in-Charge.

The rate shall include supplying (as per supply conditions given in the tender), fabricating, erecting in position (at all levels and locations), transporting, storing, testing/examining of bolted and/or welded structural steel works using (tubular/hollow sections) of all types of trusses, girders, purlins, side rails, columns, runners, beams, ties, portals, framework, bracings, brackets, sag rods etc., including all handling, straightening/bending, if required, cutting, edge preparation, welding and/or bolting of joints, providing temporary bracing, providing and fixing end caps, associated plates welded/ bolted to the tubular/ hollow sections (like gusset plates, stiffeners, fin plates, etc.), fixing in line and level with necessary temporary staging, grouting with premix, free flow, non-shrink grout as shown on drawings including preparation of detailed fabrication drawings and getting them reviewed, preparing the exposed surface for painting, surface cleaning, wire brushing, removal of mill scale, rust, oil or grease and applying the primer as specified after fabrication, return the surplus materials to the owner's stores and material reconciliation in the case of materials supplied by Owner as per relevant contract conditions etc. all complete for all the operations mentioned in the foregoing clauses.

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16.2 The weight for payment shall be determined from the fabrication drawings and respective bill of materials prepared by the Contractor. The bill of materials shall be checked and approved by the Engineer-in-Charge before making the payment. The weight shall be calculated on the basis of BIS Handbook, wherever applicable. In case sections used are different from BIS sections, then Manufacturer's Handbook shall be adopted. No allowance in weight shall be made for rolling tolerances.

16.3 Welds, bolts, nuts, washers, shims, pack plates and grout shall not be measured. The quoted rate shall be deemed to include the same.

17.0 PAYMENT

(Where design and design drawings are also included in the scope of the Contractor).

17.1 All design and design drawings shall be prepared strictly in accordance with DESIGN SPECIFICATIONS attached with this specification as Annexure - 'A'.

17.2 Payment for structural steel works fabricated and made out of tubular/hollow sections shall be made on the basis of admissible weight in metric tons (determined as described in clause 17.3 to 17.4) of the structure accepted by the Engineer-in-Charge.

The rate shall include supplying, fabricating, erecting in position (at all levels and locations), transporting, storing, testing/examining of bolted and/or welded structural steel works using (tubular/hollow sections) of all types of trusses, girders, purlins, side rails, columns, runners, beams, ties, portals, framework, bracings, brackets, sag rods etc., including all handling straightening/bending if required, cutting, edge preparation, welding and/or bolting of joints, providing temporary bracing, providing and fixing end caps, associated plates welded/ bolted to the tubular/ hollow sections (like gusset plates, stiffeners, fin plates, etc.) fixing in line and level with necessary temporary staging, grouting with premix, free flow, non-shrink grout as shown on drawings including preparation of detailed fabrication drawings and getting them reviewed, preparing the exposed surface for painting, surface cleaning, wire brushing, removal of mill scale, rust, oil or grease and applying the primer as specified after fabrication, return the surplus materials to the owner's stores and material reconciliation in the case of materials supplied by Owner as per relevant contract conditions etc. all complete for all the operations mentioned in the foregoing clauses.

17.3 The weight for payment shall be determined from the fabrication drawings and respective bill of materials prepared by the Contractor. The bill of materials shall be checked and approved by the Engineer-in-Charge before making the payment. The weight shall be calculated on the basis of BIS Handbook wherever applicable. In case sections used are different from BIS sections, then Manufacturer's Handbook shall be adopted. No allowance in weight shall be made for rolling tolerances.

17.4 Welds, bolts, nuts, washers, shims, pack plates and grout shall not be measured. The quoted rate shall be deemed to include the same.

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ANNEXURE - 'A'
(Clause no. 1.0 & 17.1)

DESIGN SPECIFICATIONS

1.0 DESIGN AND DESIGN DRAWINGS

Design shall be done based on Engineering Design Basis or Scope of Work attached with Tender document. Wherever the same is not available, the following design specification shall be adopted:

1.1 The design and design drawings of the structure(s) shall be prepared by the Contractor on the basis of conceptual drawing(s) furnished to him. These (design and design drawings) shall be prepared in his own design office, or in case such facility is not available with the Contractor, by an approved and established agency. The names of agencies who may be considered for entrusting with this work shall be submitted along with the offer for approval of the Engineer-in-Charge. If none of the agencies so named is approved, the Contractor shall submit a fresh list for approval.

1.2 The design shall be done in accordance with IS 800, IS 801, IS 806, IS 1161 & IS 4923, and other relevant BIS Codes (latest revisions). The loads to be adopted in the design shall be in accordance with IS 875 & IS 1893 except otherwise specified. All design calculations and design drawings shall be prepared in metric units i.e. dimensions in millimetres and levels in metres.

1.3 The basic consideration for design of structural framework shall primarily be its stability, ease of fabrication and erection, overall economy satisfying the relevant BIS Codes of Practice and satisfactory performance. All structures shall be designed to withstand the worst combination of loading.

1.4 Structures, in general, shall be of welded construction. Roof trusses shall have a slope of 1:3 (1 vertical : 3 horizontal). Purlins shall be spaced in such a manner so as to achieve maximum economy in the use of roof sheets. Camber (span/500) shall be provided for trusses having span of 15 meters and above. The minimum thickness of gussets shall be 8mm.

1.5 All design calculations (supplemented with necessary explanatory sketches, computer outputs & explanatory notes) shall be done in a neat and systematic manner so as to facilitate review of the same. The design drawings shall include the following:

a) Structural layout, elevations, sections.

b) Sizes of members and tables showing forces in members under different loading conditions.

c) Proposed sizes of sheets and extent of sheeting (to be represented by chain dotted lines)

d) Blown up details of typical joints, connections, splices etc.

e) Size and type of welds/bolts

f) Quality of tubular/hollow sections and structural steel bolts etc.

g) Approximate quantity (Metric Tons)

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h) Chart/table showing loading (under different conditions) and fixing details at base (required for the design of supporting structure/foundations which shall be in the Owner's scope of work)

1.6 All design calculation sheets and design drawings shall be thoroughly checked, approved, stamped "Approved For Construction" and signed by a competent design engineer (engaged by the Contractor) prior to their submission to the Engineer-in-Charge for review. Unchecked and unsigned design calculations and design drawings shall not be accepted for review and shall be returned forthwith to the Contractor.

1.7 The Contractor shall submit the design calculations (3 sets) and design drawings (6 sets) for review to the Engineer-in-Charge. Any comments/ suggestions given by him shall be incorporated in the design/ design drawings (without any extra cost to the Owner) and resubmitted for review. However, it shall be clearly understood that review by the Engineer-in-Charge shall not relieve the Contractor of his responsibility for the correctness of design, drawings and execution of the works. Any defect observed either during construction/erection or till the defect liability period of works shall be rectified and removed by the Contractor without any cost implication.

1.8 The design calculations and design drawings for the building(s) shall be submitted by the Contractor in one lot so as to facilitate an overall systematic review by the Engineer-in-Charge.

1.9 The Contractor shall supply the all native soft files of all design calculations and design drawings at no extra cost to the Owner, for record.

1.10 **Based on the final design drawings, the Contractor shall prepare necessary fabrication drawings in conformity with clause 4.0 of EIL Specification no. 6-68-0007.**

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ANNEXURE - 'B'
(Clause 10.4)

MAXIMUM PERMISSIBLE ERECTION TOLERANCES

A. COLUMNS

1. Deviation of column axes at foundation top level with respect to true axes.	
i) In longitudinal direction	± 5 mm
ii) In lateral direction	± 5 mm
2. Deviation in the level of bearing surface of columns at foundation top with respect to true level.	± 5 mm
3. Out of plumbness (verticality) of column axis from true vertical axis, as measured at top:	
i) Upto and including 30 m height	± H/1000 or ± 25 mm (whichever is less)
ii) Over 30 m height	± H/1200 or ± 35 mm (whichever is less)
4. Deviation in straightness in longitudinal and transverse planes of column at any point along the height.	± H/1000 or ± 10 mm (whichever is less)
5. Difference in the erected positions of adjacent pairs of columns along length or across width of building prior to connecting trusses/beams with respect to true distance	± 5 mm
6. Deviation in any bearing or seating level with respect to true level	± 5 mm
7. Deviation in difference in bearing levels of a member on adjacent pair of columns both across and along the building	± 5 mm

Notes:
1. Tolerance specified under 3 should be read in conjunction with 4 & 5.
2. 'H' is the column height in mm.

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B. TRUSSES:

1)	Shift at the centre of span of top chord member with respect to the vertical plane passing through the centre of bottom chord.	:	± 1/250 of Height of truss in mm at the centre of span or ± 15 mm (whichever is less)
2)	Lateral shift of top chord of truss at the centre of span from vertical plane passing through the centre of supports of the truss	:	± 1/1500 of span of truss in mm or ± 10 mm (whichever is less)
3)	Lateral shift in location of truss from its true vertical position	:	± 10 mm
4)	Lateral shift in location of purlin from true position	:	± 5 mm
5)	Deviation in difference of bearing levels of truss from the true level	:	± 1/1200 of span of truss in mm or ± 20 mm (whichever is less)

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सिविल एवं संरचनात्मक कार्य

STANDARD SPECIFICATION
CIVIL & STRUCTURAL WORKS

विभिन्न इस्पात कार्य

MISCELLANEOUS STEEL WORKS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
9	11.12.25	REVISED & REISSUED	CK	AJS	AS	MN
8	18.04.25	REVISED & REISSUED	TK	AJS	AS	MN
7	27.08.18	REVISED & REISSUED	AS	AS	RS	RKT
6	24.01.14	REVISED & REISSUED	AJS	RS	PKM	SC
5	10.06.08	REVISED & REISSUED	PKB	PKM	VK	VC

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Abbreviations:

AFC	:	Approved for Construction
BIS	:	Bureau of Indian Standards
DIN	:	Deutsches Institut für Normung (German Institute for Standardization)
EN	:	European Standards
IS	:	Indian Standard
ISO	:	International Organization for Standardization
MS	:	Mild Steel
PCC	:	Plain Cement Concrete
RCC	:	Reinforced Cement Concrete

Structural Standards Committee

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CONTENTS

1.0 GENERAL 4
2.0 REFERENCES 4
3.0 MATERIAL 4
4.0 ANCHOR BOLTS 4
5.0 METAL INSERTS 5
6.0 CHEQUERED PLATES 6
7.0 GRATINGS 7
8.0 TUBULAR HAND RAILING 8
9.0 MILD STEEL RUNGS 9
10.0 LIGHT GAUGE STEEL STRUCTURAL SECTIONS 9
11.0 MECHANICAL ANCHOR FASTENERS 10
12.0 CHEMICAL ANCHOR FASTENERS AND DOWELS 12

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1.0 GENERAL

1.1 All materials supplied by the Contractor shall conform to specifications given in EIL Standard Specification No. 6-68-0002.

1.2 The Contractor shall furnish test certificates for all materials prior to their use in the works. Structural steel materials not supported by mill test certificates may be used after confirming their quality by carrying out appropriate tests in accordance with the method specified in IS 1608.

1.3 Other requirements not covered under this specification shall be in accordance with EIL Standard Specification No. 6-68-0006.

2.0 REFERENCES

As mentioned in the respective clauses.

3.0 MATERIAL

As mentioned in the respective clauses.

4.0 ANCHOR BOLTS

4.1 Material

Materials for anchor bolts, nuts, locknuts, washers, pipe sleeves and anchor plates shall conform to their respective clauses given in EIL Standard Specification No. 6-68-0002.

4.2 Fabrication

Fabrication of anchor bolts and their complete assemblies shall be strictly in compliance with the specifications and drawings/standards.

4.3 Placement

Anchor bolt assemblies shall be placed in position strictly as per drawings and securely held during pouring and vibrating of concrete with necessary templates and other dummy structures to prevent their dislocation.

4.4 Tolerances

Tolerances allowed for anchor bolts positioning shall be as below:

a) For sleeved bolts, one tenth of the bolt nominal diameter.
b) For bolts without sleeves, one twentieth of the bolt nominal diameter.

4.5 Protection

The exposed surfaces of bolts shall be properly covered (after greasing of bolts and packing of sleeves) with jute cloth so as to protect them from damage till final erection of structure/ equipment is over.

4.6 Payment

4.6.1 Payment shall be made on the basis of actual weight in metric tons of the anchor bolt/anchor bolt assembly. The rate shall include supply (as per scope of supply conditions given in the

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tender) of all materials, handling, transporting, fabrication, turning from available size to required diameter, threading, welding, fixing in position at all levels and locations, providing necessary templates, greasing, packing of sleeves, covering with jute cloth and other protective measures etc. all complete.

4.6.2 The rate shall cover bolt of any diameter and nomenclature.

4.6.3 Payment for fixing anchor bolt assembly (already fabricated and supplied by the Owner as free issue) in position shall be made on the basis of actual weight of anchor bolts/bolt assemblies in metric tons. The rate shall include handling, transporting, fixing in position at all levels and locations, welding if required, providing necessary templates, greasing, packing of sleeves, covering with jute cloth and other protective measures etc. all complete.

4.6.4 No separate payment shall be made for templates, dummy structures, supports etc. and the rate quoted shall be inclusive of all cost related to such provision required for correct and accurate installation of anchor bolts/anchor bolt assembly.

5.0 METAL INSERTS

5.1 Material

Materials required for fabricating metal inserts shall conform to their respective specification given in EIL Standard Specification No. 6-68-0002.

5.2 Fabrication

Fabrication of inserts shall be done strictly as per drawings/standards and in compliance with the requirements given in EIL Standard Specification No. 6-68-0006.

5.3 Placement

Metal inserts shall be correctly embedded (in plain concrete/ reinforced concrete) as per their location shown on the drawings. Care shall be taken that these are securely held in position and do not get disturbed during concreting. Where necessary, these may be welded to the reinforcement bars. Suitable templates, spacers, dummy structures and temporary staging shall be provided. Necessary cutting in the formwork and adjustment of reinforcement bars shall be done for the placement of metal inserts where required.

5.4 Painting

The exposed surfaces of metal inserts shall be cleaned and given one coat of primer as per EIL Standard Specification No. 6-79-0020 or job specification (wherever applicable), as specified, after fabrication.

5.5 Payment

Payment shall be made on the basis of actual weight in metric tons of the metal inserts. The rate shall include supply (as per supply conditions given in the tender) of all materials, handling, transporting, fabrication, welding, fixing in position at all levels and locations, providing necessary templates, spacers, dummy structures, adjusting the formwork and reinforcement, staging, preparation of surface for painting, applying one coat of primer as per EIL Standard Specification No. 6-79-0020 or job specification (wherever applicable), as specified, etc. all complete.

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6.0 CHEQUERED PLATES

6.1 Material

Material required for chequered plates shall conform to the specifications given in EIL Standard Specification No. 6-68-0002. Chequering shall be closed or open-ended or of any other pattern as shown on drawings.

6.2 Fabrication Drawings

As per the requirements given in EIL Standard Specification No. 6-68-0006.

6.3 Fabrication

Chequered plates shall be fabricated as per the "Approved for Construction" fabrication drawings (prepared by the Contractor based on design drawings). These shall be perfectly flat and without any dents/deformations and shall be cut to the required size and shape. Holes/ notches/ openings of the required size, if any, shown on drawings shall be made. Nosing for staircase treads shall be made by cold bending of chequered plates. All edges shall be made smooth and even. All chequered plate units shall be given distinct erection marks in accordance with the marking drawings. Stiffeners of any description shall be welded with the chequered plates where shown on drawings.

6.4 Erection/Fixing

Chequered plates shall be fixed to the bearing members by welding/ bolting/ screwing as shown on drawings. All bolts/ screws shall be of counter-sunk type so that the heads remain flush with the top of plate. Where welding is used for fixing, stitch welds of minimum 50mm length with a pitch of 150 mm shall be used. Continuous sealing run of weld shall be provided along the junction of two consecutive chequered plates parallel to the span. For removable flooring, details as shown on drawings shall be followed.

6.5 Painting

Chequered plates shall be cleaned (both the surfaces) and given one coat of primer/ galvanization as per EIL Standard Specification No. 6-79-0020 or job specification, as specified, on both surfaces.

6.6 Payment

6.6.1 Payment shall be made on the basis of actual weight in metric tons of the chequered plate. If any stiffening sections are provided below the chequered plates for strengthening, the same shall be separately measured & paid under Structural Steel item (Refer EIL Standard Specification No. 6-68-0006).

6.6.2 The rate shall include supplying (as per supply conditions given in the tender), fabricating, erecting M.S. chequered plates including transporting, handling, straightening if required, cutting to required size and shape, making holes/ notches/ opening of required size and nosing, smoothening the edges, fixing by welding/bolting/screwing, at all levels and locations, preparing detailed fabrication drawings, surface cleaning, removal of rust, scale, grease and applying one coat of primer/ galvanization as per EIL Standard Specification No. 6-79-0020 or job specification (wherever applicable), as specified, etc. all complete.

6.6.3 Welds, bolts, nuts, screws, washers, clips shall not be measured. The quoted rate shall be deemed to include the same.

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7.0 GRATINGS

7.1 Categories

Electroforged Carbon Steel/ Stainless Steel gratings shall be either Type-I or Type-II as per EIL Standard No. 7-68-0697 and shall be procured from approved manufacturers as per Departmental List of Approved Manufacturers.

7.2 Material

Materials for fabrication and fixing of Gratings shall conform to EIL Standard No. 7-68-0697 and EIL Specification No. 6-68-0002.

7.3 Fabrication Drawings

As per the requirements given in EIL Standard Specification No. 6-68-0006.

7.4 Fabrication

The gratings shall be manufactured by electroforging process strictly as per the "Approved for Construction" fabrication drawings prepared by the Contractor based on EIL standard. All units shall be given distinct erection marks in accordance with the marking drawing. The Contractor shall submit sample gratings for inspection and approval by the Engineer-in-Charge whenever asked for.

7.5 Erection/Fixing

Gratings shall be fixed to the bearing members by welding, clamping/ disc and bolting/ studs as indicated in the Standard.

7.6 Galvanisation

Carbon steel gratings and the fixing clamps, bolts, nuts shall be cleaned as per EIL Standard Specification No 6-79-0020 or job specification (wherever applicable), as specified and galvanisation shall be done as specified in accordance with IS 2629 and tested as per IS 2633 & IS 6745. Carbon Steel Disc & Stud shall either be hot dip galvanized or shall have a coating that can withstand neutral salt spray test of 2000H as per DIN EN ISO 9227.

7.7 Payment

7.7.1 Payment shall be made on the basis of actual weight in metric tons of the gratings manufactured in accordance with EIL Standard and accepted by the Engineer-in-Charge.

The weight for payment shall also include the weight of galvanization and welding.

7.7.2 The rate shall include supplying, fabricating, erecting electroforged Carbon steel/ Stainless steel gratings (of the specified category) including transporting, handling, cutting to required size and shape, making holes/ notches/ openings, smoothening the edges, fabricating clamps/discs, fixing by welding/ clamping/ bolting/ disc & stud, at all levels and locations, preparing detailed fabrication drawings, surface cleaning, removal of rust, scale, grease and carrying out galvanization on Carbon steel gratings, clamps, nuts & bolts and/or a coating on Carbon steel discs & studs that can withstand neutral salt spray test of 2000H as per DIN EN ISO 9227, repairing the damaged area of galvanized coating using cold galvanizing spray process for Carbon steel grating, chemical treatment of Stainless steel grating, etc. all complete.

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7.7.3 Bolts, clamps/ discs, nuts/ studs and washers for both Carbon steel and Stainless steel gratings shall not be measured. The quoted rate shall be deemed to include the same.

8.0 TUBULAR HAND RAILING

8.1 Material

Materials for fabrication and fixing of Tubular Hand Railing shall confirm to specification given in EIL Standard Specification No. 6-68-0002.

8.2 Fabrication Drawings

As per the requirements given in EIL Standard Specification No. 6-68-0006.

8.3 Fabrication

8.3.1 Hand railing shall be fabricated strictly as per the "Approved for Construction" fabrication drawings prepared by the Contractor based on design drawings and standards. All tubes shall be straight and without any dents/ deformations. Tubes shall be cut and ends shall be prepared to a neat and workman-like finish. All elements shall be directly welded. All welded joints shall be cleaned and filed or ground smooth, if required, to have a smooth surface and aesthetically pleasant appearance. Splicing of top rail shall not be allowed. Tubes shall be cold bent to shape and curvature in case of discontinuous ends of handrails. Ripples, kinks and/ or dents at bends shall not be accepted.

8.3.2 Lower ends of vertical posts shall be cut and splayed (for grouting in pockets in the concrete members). For removable type of hand railing, suitable base plates (with provision for bolting) shall be welded to the lower end of vertical posts. All units shall be given distinct erection marks in accordance with the marking drawing.

8.4 Erection/ Fixing

Hand railing shall be fixed to the bearing members by welding/ bolting/ grouting as indicated on the drawings. Local notching shall be made in the floor plate/ grating to accommodate vertical posts/ their base plates which shall always be welded to the main supporting member. When the posts are to be fixed in concrete members, suitable pockets shall be made in concrete for grouting as shown on drawings/standards.

8.5 Painting

All hand railing components shall be cleaned and given one coat of primer/ galvanization as per EIL Standard Specification No. 6-79-0020 or job specification (wherever applicable), as specified, after fabrication.

8.6 Payment

8.6.1 Payment shall be made on the basis of measured length in meters (m) of top rail only (Horizontal and/or inclined lengths). The rate shall include preparation of fabrication drawings, supply of all materials, handling, transporting, straightening if required, cutting to required size, bending, welding, bolting, fixing in position at all levels and locations, grouting with 1:2 (cement: sand) mortar, surface cleaning, removal of rust, scale, grease and applying one coat of primer/ galvanization as per EIL Standard Specification no. 6-79-0020 or job specification (wherever applicable), as specified, after fabrication etc. all complete.

8.6.2 The rate shall include making suitable notches in floor plates/ gratings and pockets in concrete structures for fixing the vertical posts.

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9.0 MILD STEEL RUNGS

9.1 Material

All materials shall conform to specifications given in EIL Standard Specification No. 6-68-0002.

9.2 Fabrication

Rungs shall be fabricated as per EIL standards/ drawings. Mild steel bars shall be straightened if required, cut, bent to shape and given one coat of primer and two coat of finish paints per EIL Standard Specification No. 6-79-0020 or job specification (wherever applicable) as specified, on exposed portions after fabrication.

9.3 Fixing

Rungs shall be fixed in position as per detailed drawing and firmly tied/welded with reinforcement to prevent their displacement during vibration of concrete.

9.4 Payment

Payment shall be made on the basis of actual weight in kilogram (Kg) of the M.S. rungs. The rate shall include supply of all materials, handling, transporting, straightening if required, cutting to required size, bending to shape, tying/welding with reinforcement bars, fixing at all levels and locations, adjustment of formwork, applying one coat of primer and two coats of finish paint as per EIL Standard Specification No. 6-79-0020 or job specification (wherever applicable), as specified, on the exposed portion of rungs etc. all complete.

10.0 LIGHT GAUGE STEEL STRUCTURAL SECTIONS

10.1 Material

All materials required for fabrication and fixing in position of Light Gauge Steel Structural Sections shall conform to EIL Standard Specification No. 6-68-0002.

10.2 Fabrication Drawings

As per the requirements given in EIL Standard Specification No. 6-68-0006.

10.3 Fabrication

10.3.1 Fabrication of members shall be done strictly as per the "Approved for Construction" fabrication drawings prepared by the Contractor based on the latest design drawings and in accordance with IS 800, IS 801 and other relevant BIS Codes.

10.3.2 All members shall be straight and free from any dents/deformations/ twists. Members shall be cut to the required sizes and ends prepared to a neat and workman like finish. Holes (for sag rods and cleat bolts) of appropriate size shall be drilled and all members/ components shall be given distinct erection marks in accordance with the marking drawings. Holes shall not be formed by gas cutting process.

10.4 Erection

Structural members shall be erected in proper sequence and aligned properly without causing any twist. Permanent bolting/ welding shall be done only after proper alignment has

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been achieved. Proper access, working platforms and safety arrangements shall be provided by the Contractor for working and inspection.

10.5 Painting

All structural components shall be cleaned and given one coat of primer as per EIL Standard Specification No. 6-79-0020 or job specification (wherever applicable), as specified, after fabrication.

10.6 Payment

10.6.1 Payment shall be made on the basis of admissible weight in metric tons of the structure accepted by the Engineer-in-Charge. The weight for payment shall include all structural members, cleats, splices, gussets and sag rods and shall be determined from the fabrication drawings along with respective bill of materials prepared by the Contractor. The bill of materials shall be checked and approved by the Engineer-in-Charge before making the payment. The weight shall be calculated as per IS 808/ IS 1161. BIS Handbook/ Manufacturer's catalogues/ charts shall be adopted in case relevant weights of sections used are not covered in IS 808/ IS 1161. No allowance in weight shall be made for rolling tolerances. In case of any doubt, actual weight of the section shall be measured at site.

The rate shall include supplying, fabricating, erecting, at all levels and locations, testing of bolted and/ or welded Light Gauge structural steel works including cleats, crook bolts, splices/ sleeves, all other fixtures and accessories, straightening if required, cutting, edge preparation, welding and bolting of joints, fixing in line and level with temporary staging and removal of the same after final alignment, handling, transporting, storage, preparation of detailed fabrication drawings and getting them reviewed by the Engineer-in-Charge, surface cleaning, removal of scale, rust, oil or grease and applying one coat of primer as per EIL Standard Specification No. 6-79-0020 or job specification (wherever applicable), etc., all complete.

10.6.2 All welds, bolts, nuts, washers, fixtures and accessories shall not be measured. The quoted rate shall be deemed to include the same.

11.0 MECHANICAL ANCHOR FASTENERS

Design and testing of Mechanical Anchor Fasteners shall conform to IS 1946 Part-2 and Part-4 respectively or they shall be approved by European Organization for Technical Approval (EOTA) / Deutsches Institut für Bautechnik (DIBt)/ Factory Mutual Laboratories (FM)/ International Code Council- Evaluation Services (ICC-ES formerly ICBO-ES) for use in Cracked Concrete.

Design of post-installed Mechanical anchor fasteners shall be provided/ verified by the approved manufacturer with installation instructions and execution shall be done by an applicator trained by the approved manufacturer (preferably in the presence of manufacturer for critical applications/ structures).

11.1 Material

Mechanical Anchor Fasteners shall be of minimum grade 5.8 galvanised to at least 5 microns or Stainless Steel (SS304 or SS316) and shall be approved for use in cracked concrete.

Stainless steel Mechanical anchor fasteners shall be preferred for sites located in coastal areas or in high rainfall zone.

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11.2 Classification

11.2.1 Mechanical anchor fasteners shall be of following types:

a) Wedge/ Expansion anchor fasteners

They are most commonly used anchor fasteners and shall be utilized in safety related installations, fixing of insert or base plate for beams & columns, jacking of column, staircase railing, handrails, racks, walkways, pipe supports, ladders, jacketing, platform supports, strengthening of structure, knee supports, fire sprinklers, concrete formwork, telecommunication equipments, etc.

b) Screw anchor fasteners

They shall be used for installation of door & window frames, fences, facade panels, cable trays, electrical fixtures, hangers, sill plates, Signages, temporary fabrications, formwork props, Tilt ups & Prefab connectors, etc.

c) Undercut anchor fasteners

They shall be used only for critical applications with prior design assistance from the manufacturer, like for fixing pumps, turbines, industrial exhaust fans, heavy pipes, crane rails, crash & safety barriers, industrial machines, heavy platform supports, knee brackets with heavy loads, supports subjected to cyclic/dynamic loadings (shock, seismic & fatigue), etc.

11.2.2 Mechanical anchor fasteners shall be designated as medium and heavy duty depending on their usage. The broad classification is given below for general guidance.

11.2.2.1 Medium Duty for:

a) Ladders, balconies and stairs support.
b) Cables and cable trays support.
c) Electrical panels and fixtures.
d) Hangers for pipes and cable trays
e) Secondary & tertiary Pipe supports.
f) Equipment Skids
g) Formwork props, tilt ups and prefab connectors.
h) Small Industrial equipments.

11.2.2.2 Heavy Duty for:

a) Platform supports (beam and columns)
b) Knee brackets for pipes/ multi tiers cable trays/ walkways etc.
c) Foundation anchors for heavy equipment like boiler, silos, etc.
d) Primary connection for erection of Beams & Columns for missing insert/ base plates
e) Primary pipe supports, Industrial machines
f) Safety barriers, Crash barriers, Crane rails, dorm structures
g) Elevator tracks, Car hoists, roof & slab supports

11.2.3 Necessary support shall be taken from the Manufacturer while deciding the Mechanical anchor fasteners for following applications:

a) Members supporting equipment and pipes subjected to vibrations.
b) Cantilever connections designed to cater for effective cantilever spans greater than 1m and concentrated load of more than 10KN at the free end.

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11.3 Selection

The Contractor shall procure the Mechanical anchor fasteners from the approved manufacturers as per Departmental List of Approved Manufacturers.

11.4 Testing

If so desired by the Engineer-in-Charge, the Contractor shall carry out all the requisite tests (pullout test, torque test etc.) of specimen Mechanical anchor fasteners (representative of those to be used) from approved laboratory/ test house and submit the report to him for approval. The decision of the Engineer-in-Charge regarding the adequacy of strength and load carrying capacity of Mechanical anchor fasteners shall be final and binding to all. The cost of all such tests shall be borne by the Contractor.

11.5 Installation

The Contractor shall install Mechanical anchor fasteners at their correct location (to suit the requirement of fixtures as shown in drawings) as per the procedure laid down by the manufacturer. Location of all holes shall be pre-marked on the concrete surfaces. Scanning before drilling shall be done with appropriate ferro scanner tool to avoid rebar hits and structural damage. The holes shall then be drilled carefully with an electric drill to the correct recommended size and depth. Holes shall be exactly round and true perpendicular to the concrete surface. Edge distance and pitch of fasteners shall be as recommended by the manufacturer. The contractor shall suitably shift the hole with the approval of the Engineer-in-Charge in case any reinforcement bar is encountered while scanning/ drilling the hole in RCC structure. Anchors shall preferably be driven with the help of setting tool, fixed at right embedment depth, by applying torque using calibrated impact wrench as per manufacturer's instructions. Necessary staging shall be provided for working and the Contractor shall take requisite safety precautions so as not to cause any damage to the existing structure/ equipment. Any damage done while executing the job shall be made good by the Contractor at his own cost.

11.6 Protection

The exposed surfaces of Mechanical anchor fasteners shall be properly greased & covered with jute cloth so as to protect them from damage.

11.7 Payment

Payment for installing rust proof Mechanical anchor fasteners shall be made on number basis (each). The rate shall include supply of complete assembly, handling, transporting, providing necessary temporary staging, installing (as per manufacturer's specifications) in PCC/ RCC structures, at all levels and locations, testing, scanning, drilling, cleaning, covering with jute cloth, relocating and re-drilling in case of any obstruction, making good any damage done to the structure, grouting the abandoned holes and any gap left between the contact surfaces of PCC/ RCC and fixtures to be added, design assistance from the Manufacturer (wherever required), etc. all complete.

12.0 CHEMICAL ANCHOR FASTENERS AND DOWELS (REBARS)

Design and testing of Chemical anchor fasteners including Adhesive (Chemical) shall conform to IS 1946 Part-2 & Part-3 respectively or they shall be approved by European Organization for Technical Approval (EOTA)/Centre Scientifique et Technique du Bâtiment (CSTB)/ Code Officials and Laboratory Accreditation (COLA)/ International Code Council-Evaluation Services (ICC-ES formerly ICBO-ES) for use in Cracked Concrete. They shall

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have Seismic (Zone III & above equivalent), Fatigue, Shock and Fire approvals from European Technical Assessment (ETA) agency.

The adhesive (Chemical) shall have an ETA approval for 100 years of age testing and shall comply with EOTA Technical Report (TR 029)/ EN 1992-4 while using with Chemical anchor fasteners and EOTA Technical Report (TR 069) & European Assessment Document (EAD 332402-00-0601) while using with Dowels (Rebars).

Design of post-installed Chemical anchor fasteners and Dowels (Rebars) shall be provided/ verified by the approved manufacturer with installation instructions and execution shall be done by an applicator trained by the approved manufacturer (preferably in the presence of manufacturer for critical applications/ structures).

12.1 Material

Chemical anchor fasteners shall be of high tensile steel rods of minimum grade 5.8 galvanised to at least 5 microns or Stainless Steel (SS304 or SS316) and shall be approved for use in cracked concrete.

Stainless steel Chemical anchor fasteners shall be preferred for sites located in coastal areas or in high rainfall zone.

Rebars used as dowels shall be of grade as per General Notes of the project.

12.2 Selection

The Contractor shall select the chemical anchor fasteners based on the parameters such as Loads and rebars for dowels as specified in the AFC drawings/ documents. The chemical anchor fasteners shall be procured from the approved manufacturers as per Departmental List of Approved Manufacturers.

12.3 Testing

The Contractor shall carry out, at the work place, the requisite tests like pull out test, shear test, etc. for chemical anchor fasteners and pull out test for dowels (rebars). The chemical anchor fasteners shall withstand the load specified in the drawing/ documents and the Dowels (rebars) shall be tested for full tensile capacity of the rebars. The decision of the Engineer-in-Charge regarding the adequacy of strength and load carrying capacity of the anchor fasteners/ dowels (rebars) shall be final and binding to all. The cost of all such tests shall be borne by the Contractor.

12.4 Installation

The Contractor shall install the chemical anchor fasteners/ dowels (rebars) at their correct location (to suit the requirement of fixtures as shown in drawings) as per the procedure laid down by the manufacturer. Location of all holes shall be pre-marked on the concrete surfaces. Scanning before drilling shall be done with appropriate ferro scanner tool to avoid rebar hits and structural damage. The holes shall then be drilled carefully with an electric drill to the correct recommended size and depth. Holes shall be exactly round and true perpendicular to the concrete surface. Edge distance and pitch of fasteners shall be as recommended by the manufacturer. The contractor shall suitably shift the hole with the approval of the Engineer-in-Charge in case any reinforcement bar is encountered while scanning/ drilling the hole in RCC structure. The adhesive (chemical) shall preferably be dispensed with the help of battery operated dispenser gun & mixer nozzle to avoid over/ under dosing & void creation. Piston plugs and extension pipe shall be used for embedment depths beyond 300 mm. Anchors shall preferably be driven with the help of setting tool,

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fixed at right embedment depth, by applying torque using calibrated impact wrench as per manufacturer's instructions. Necessary staging shall be provided for working and the Contractor shall take requisite safety precautions so as not to cause any damage to the existing structure/ equipment. Any damage done while executing the job shall be made good by the Contractor at his cost.

12.5 Payment

Payment for installing chemical anchor fasteners shall be made on number basis (each). The rate shall include supply of complete assembly i.e. chemical anchor fasteners along with adhesive (chemical) foils as per manufacturer specifications.

Payment for installing chemical dowels (rebars) shall be made on number basis (each). The rate shall include fixing of dowels (rebars) by drilling/ cleaning hole and injecting odourless adhesive (chemical) as per manufacturer specifications. Rebars used as dowels shall be paid separately under relevant SOR item.

For chemical anchor fasteners/ dowels (rebars), the rate shall be inclusive of handling, transporting, providing necessary temporary staging, installing (as per manufacturer's specifications) in PCC/ RCC structures to a required depth with a specified hole diameter, at all levels and locations, testing, scanning, drilling holes, cleaning, covering with jute cloth, relocating and re-drilling in case of any obstruction, making good any damage done to the structure, grouting the abandoned holes and any gap left between the contact surfaces of PCC/ RCC and fixtures to be added, design assistance from the Manufacturer (wherever required), etc. all complete.

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सिविल एवं संरचनात्मक कार्य

STANDARD SPECIFICATION
CIVIL & STRUCTURAL WORKS

ईंट की चिनाई

BRICK MASONRY

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	11.12.25	REVISED & REISSUED AS STANDARD SPECIFICATION	Chandan	Amarjeet	Anurag Sinha	M.Nandi
5	21.12.20	REVISED & REISSUED AS STANDARD SPECIFICATION	AS	RBS	AS	SM
4	10.03.16	REVISED & REISSUED AS STANDARD SPECIFICATION	MK	AJS	RS	S Chanda
3	14.05.10	REVISED & REISSUED AS STANDARD SPECIFICATION	YPC	PKM	SC	N Duari
2	06.04.00	REAFFIRMED & ISSUED	SBJ	SKP	SCJ	MI

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Abbreviations:

ASTM	:	American Society for Testing and Materials
BIS	:	Bureau of Indian Standards
IS	:	Indian Standards

Structural Standards Committee:

Convener: Mr. Anurag Sinha

Members: Mr. Virender Goel
Mr. Deepak Agrawal
Ms. Alpana Srivastava
Dr. Sudip Paul
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CONTENTS

1.0 SCOPE 4

2.0 REFERENCES 4

3.0 MATERIALS 4

4.0 GENERAL REQUIREMENTS 4

5.0 CONSTRUCTION PROCEDURE 5

6.0 PAYMENT 9

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1.0 SCOPE

This specification establishes the materials, dressing, laying, joining, curing, workmanship etc. for brick masonry works. Brick masonry shall also comply with all the requirements of IS 2212.

2.0 REFERENCES

2.1 Standards

S. No.	IS No.	Title
1.	IS 2212	Brick work- code of practice
2.	IS 2250	Code of practice for preparation and use of Masonry mortars
3.	IS 2750	Specification for Steel Scaffoldings
4.	ASTM C 1714	Standard Specification for Preblended Dry Mortar mix for unit masonry

2.2 EIL specification

6-68-0002: Materials

3.0 MATERIALS

Refer EIL Specification No. 6-68-0002.

4.0 GENERAL REQUIREMENTS

4.1 Cement Mortar

Cement mortar shall meet the requirements of IS 2250 and shall be prepared by mixing cement and sand by volume. Proportion of cement and sand shall be 1:6 (1 part of cement and 6 parts of sand), or as directed by the Engineer-in-Charge/shown on the drawing, for brick masonry of one brick thickness or more, while 1:4 cement mortar (1 part of cement and 4 parts of sand) shall be used for brick masonry of half brick thickness. The sand being used for mortar shall be sieved. The mortar shall be used as soon as possible after mixing and before it has begun to set and in any case within initial setting time of cement after water is added to the dry mixture. Mortar unused for more than initial setting time of cement, shall be rejected and removed from the site of work.

4.1.1 Proportioning

The unit of measurement for cement shall be a bag of cement weighing 50 Kg and this shall be taken as 0.035 cubic metre. Sand shall be measured in boxes of suitable size on the basis of its dry volume. In case of damp sand, its quantity shall be increased suitably to allow for bulkage.

4.1.2 Mixing

The mixing of mortar shall be done in a mechanical mixer operated manually or by power. The Engineer-in-Charge may, however, permit hand-mixing as a special case, taking into account the magnitude, nature and location of work. The Contractor shall take the prior

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permission of Engineer-in-Charge, in writing, for using hand-mixing before the commencement of work.

4.1.2.1 Mixing in Mechanical Mixer

Cement and sand in specified proportions, by volume, shall be thoroughly mixed dry in a mixer. Water shall then be added gradually and wet mixing continued for atleast one minute. Care shall be taken not to add more water than that which shall bring the mortar to the consistency of stiff paste. Wet mix from the mixer shall be unloaded on water-tight masonry platform, made adjacent to the mixer. Platform shall be atleast 150 mm above the levelled ground to avoid contact of surrounding earth with the mix. Size of the platform shall be such that it shall extend atleast 300mm alround the loaded wet mix area. Wet mix, so prepared, shall be utilised within initial setting time of cement after addition of water. Mixer shall be cleaned with water each time before suspending the work.

4.1.2.2 Hand Mixing

The measured quantity of sand shall be levelled on a clean water-tight masonry platform and cement bags emptied on top. The cement and sand shall be thoroughly mixed dry by being turned over and over, backward and forward, several times till the mixture is of uniform colour. The quantity of dry mix which can be consumed within initial setting time of cement shall then be mixed with just sufficient quantity of water to bring the mortar to the consistency of stiff paste.

4.2 Ready mix Preblended Mortar

Packaged ready to use preblended dry mortar mix conforming to ASTM C 1714 or equivalent shall also be used for joining the masonry units with prior approval of Engineer-in-Charge.

4.2.1 Ingredients

Ready mix preblended mortar package shall consist of cement, graded sand, flyash, additive polymers or a combination thereof as per manufacturer's specification.

4.2.2 Mixing

The dry ready mix mortar shall be added to an appropriate amount of potable water (not vice-versa) as per manufacturer's recommendation. Mixing shall be done slowly by using manual/ electrical stirrer to form a uniform paste free from lumps. The paste shall be kept undisturbed for few minutes as specified allowing ingredients to react properly. The paste shall then be applied in specified thickness within the time limit as per manufacturer's recommendation.

5.0 CONSTRUCTION PROCEDURE

5.1 Soaking of Bricks

Bricks shall be soaked in water before use for a period that is sufficient for the water to just penetrate the whole depth of bricks as well as to remove dirt, dust and sand. Proper soaking of bricks shall prevent the suction of water from the wet mortar as otherwise mortar will dry out soon and crumble before attaining any strength. The bricks shall not be too wet at the time of use as they are likely to slip on mortar bed and there will be difficulty in achieving the plumbness of wall as well as proper adhesion of bricks to mortar. The period of soaking shall be determined at site by a field test by immersing the bricks in water for different periods and then breaking the bricks to find the extent of water penetration. The least period

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that corresponds to complete soaking, will be the one, to be allowed for in the construction work.

The soaked bricks shall be stacked over a clean place, wooden planks or masonry platforms to avoid earth, dirt being smeared on them. It shall be ensured that at the time of laying of soaked bricks, they are skin dry.

5.2 Laying

5.2.1 Brick Work (one or more brick thickness)

Brick work (one or more brick thickness) shall be laid in English Bond unless otherwise specified. Half or cut bricks shall not be used except when needed to complete the bond. In no case the defective bricks shall be used.

A layer of average thickness of 10mm of cement mortar shall be spread on full width over a suitable length of lower course or the concrete surface. In order to check and achieve uniformity in masonry, the thickness of bed joints shall be such that four courses and three joints taken consecutively shall measure equal to four times the actual thickness of the brick plus 30mm. Each brick with frog upward, shall be properly bedded and set in position by gently tapping with handle of trowel or wooden mallet. Its inside faces shall be buttered with mortar before the next brick is laid and pressed against it. After completion of the course, all vertical joints shall be filled from top with mortar.

All brick courses shall be taken up truly plumb; if battered, the batter is to be truly maintained. All courses shall be laid truly horizontal and vertical joints shall be truly vertical. The level and verticality of work in walls shall be checked up at every one metre interval.

The masonry walls of structures shall be carried up progressively, leaving no part one metre lower than the other. If this cannot be adhered to, the brick work shall be raked back according to bond (and not left toothed) at an angle not more than 45 degrees but raking back shall not start within 60 cm of a corner. In all cases returns, buttresses, counter forts, pillars etc. shall be built up carefully course by course, and properly bonded with the main walls. The brick work shall not be raised more than fourteen (14) courses per day.

At the junction of any two walls, the bricks shall at each alternate course, be carried into each of the respective walls so as to thoroughly unite the work.

The courses at the top of plinth and sills, at the top of the wall just below the soffit of the roof slab or roof beam and at the top of the parapet, shall be laid with bricks on edge. Brick on edge course shall be so arranged as to tightly fit under the soffit of the roof beam or roof slab, restricting the mortar layer thickness upto 12mm. However, any gap between the finished brick work and soffit of roof slab/beam shall be suitably sealed with the mortar.

5.2.2 Brick Work (half brick thickness)

For brick walls of half brick thickness, all courses shall be laid with stretchers. Wall shall be reinforced with 2 nos. - 6mm diameter mild steel bars, placed at every fourth course. The reinforcement bars, shall be straightened and thoroughly cleaned. Half the mortar thickness for the bedding joint shall be laid first and tor steel reinforcement, one on each face of the wall, shall be embedded, keeping a side cover of 12mm mortar. Subsequently, the other half of the mortar thickness shall be laid over the reinforcement covering it fully.

The reinforcement bars shall be carried at least 150mm into the adjoining walls or RCC columns. In case the adjoining wall being of half brick thickness, the length of bars shall be

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achieved by bending the bars in plan. During casting of reinforced concrete columns, 6mm dia. mild steel bars shall be placed at every fourth course of brick masonry. At the junction of two walls, the brick shall, at each alternate course, be carried into each of the respective walls so as to thoroughly unite the work. The brick masonry work shall not be raised more than 14 courses per day.

Brick course under the soffit of beam or slab, shall be laid by restricting the mortar thickness to 12mm. However, any gap between the finished brickwork and soffit of slab/beam, shall be suitably sealed with the mortar.

5.2.3 Cavity Walls

Brick work in cavity walls shall be similar to general brickwork. It shall consist of one wall of one or more brick thickness while the other wall shall be of half brick thickness at a clear gap of 50mm. The brick work on either side of cavity shall conform to the specifications already as stated in Cl. No. 5.2.1 and 5.2.2. At the base of the cavity wall, the walls shall be solidly constructed upto 300mm above the ground level. The cavity wall shall be terminated 300mm below the soffit of roof slab/beam and the courses over this shall be continued as solid brickwork.

Cavity should be continuous and free from obstructions. Mortar droppings shall be prevented from falling down the cavity by the use of laths or by hayhands which shall be drawn up the cavity as the work proceeds. Any mortar which may unavoidably fall on the wall-ties, shall be removed daily and temporary openings shall be provided to permit the daily removal of mortar droppings from the bottom of the cavity.

The outer and inner leaves shall be tied by means of wall ties. Ties shall be of tor steel bars of 8mm dia. 200 mm long with hooks at both the ends. These shall be placed not more than 750mm c/c horizontally and not more than 300mm vertically, and staggered. Additional ties shall be provided near the openings. There shall at least, be 5 ties per square metre of surface area of the wall. Ties shall be given a bituminous coat before placement, to protect them from corrosion.

In order to keep the cavity dry, air slots shall be provided in the cavity walls at bottom as well as top to the extent of 50 sq.cm area of vents to every 2.0 sq.metre area of the wall.

5.2.4 Circular Brick Work

The detailed specification for brick work covered under clauses 5.2.1 & 5.2.2 shall also apply for circular brickwork. Bricks forming skew backs, shall be dressed or cut so as to give proper radial bearing. Defects in dressing of bricks shall not be covered up by extravagant use of mortar, nor shall the use of chips etc. be permitted.

The circular brick work shall be carried up from both ends simultaneously and keyed in the centre. The bricks shall be flushed with mortar and well pressed into their positions so as to squeeze out a part of their mortar and leave the joints thin and compact. All joints shall be full of mortar and thickness of joints shall be between 5mm and 15mm.

5.3 Jointing

Joints shall be restricted to a width of 10mm with brickwork of any classification. All bed joints shall be normal to the pressure upon them i.e. horizontal in vertical walls, radial in circular brick masonry and at right angles to the face in the battered retaining walls. The vertical joints in alternate courses shall come directly one over the other and shall be truly vertical. Care shall be taken that all the joints are full of mortar, well flushed up. In case no pointing is to be done, cement mortar shall be neatly struck as the work proceeds. The joints

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in faces which are to be plastered or pointed shall be squarely raked out to a depth of 12mm while the mortar is still green. The rake joints shall be brushed to remove loose particles. After the day's work, the faces of the brick work shall be cleaned on the same day with wire brush and all mortar droppings removed.

5.4 Curing

Green work shall be protected from rain or any other running water or accumulated water from any source, by suitable means. Masonry work with conventional cement mortar, as it progresses, shall be kept thoroughly wet by sprinkling water at regular intervals, on all faces. Curing shall be done after 24 hours of completion of day's work as per IS 2212.

Curing of masonry work with ready mix preblended mortar is generally not required as the mix contains self curing polymers. However, manufacturer's specification shall be followed.

5.5 Staging/Scaffolding

5.5.1 Staging/scaffolding shall be properly planned and designed by the Contractor. Use of only steel tubes is permitted for staging/scaffolding. Design of staging/scaffolding shall be submitted for approval of the Engineer-in-Charge, before commencement of work.

Single scaffolding having one set of vertical support, shall be used and other end of the horizontal scaffolding member shall rest in a hole provided in the header course. The support shall be sound and strongly clamped with the horizontal pieces over which the scaffolding planks shall be fixed. The holes left in the masonry work for supporting the scaffolding shall be filled and made good with plain cement concrete of grade 1:2:4 (M15) during plastering. Suitable access shall be provided to the working platform area. The scaffolding shall be strong enough to withstand all loads likely to come upon it and shall also meet the requirements specified in IS 2750.

Double scaffolding shall be provided for pillars less than one metre in width or for the first class masonry or for a building having more than two storeys.

Following measures shall also be considered during erection of the scaffolding/ staging:

a) Sufficient sills or underpinnings, in addition to base plates, shall be provided, particularly, where scaffoldings are erected on soft grounds.

b) Adjustable bases to compensate for uneven ground shall be used.

c) Proper anchoring of the scaffolding/staging at reasonable intervals shall be provided in each direction with the main structure wherever available.

d) Horizontal braces shall be provided to prevent the scaffolding from rocking.

e) Diagonal braces shall be provided continuously from bottom to top between two adjacent rows of uprights.

f) The scaffolding/staging shall be checked at every stage for plumb line.

g) Wherever the scaffolding/staging is found to be out of plumb line, it shall be dismantled and re-erected afresh. Efforts shall not be made to bring it in line with a physical force.

h) All nuts and bolts shall be properly tightened and care shall be taken that all the clamps/couplings are firmly tightened to avoid slippage.

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i) Erection work of a scaffolding/staging, under no circumstance shall be left totally to semiskilled or skilled workmen and shall be carried out under the supervision of Contractor's technically qualified civil engineer.

5.5.2 For smaller works or works in remote areas wooden ballies may be permitted for scaffolding/staging by the Engineer-in-Charge at his sole discretion. The contractor must ensure the safety and suitability of such works as described under clause 5.5.1 above.

5.6 Embedment of Fixtures

All fixtures, pipes, conduits, holdfasts of doors and windows etc. required to be built in walls, shall be embedded in plain cement concrete block of grade 1:2:4 (M15), at the required positions, as the work proceeds.

6.0 PAYMENT

This clause shall apply to Item Rate tender only.

6.1 General

The payment of brick masonry shall be inclusive of all labour, material, scaffolding/staging sampling and testing, soaking of bricks, laying of bricks, raking of joints, cutting of bricks, providing recesses and making rectangular or round openings, sealing the gap between brick masonry and soffit of beam/slab with and including cement mortar/ ready mix preblended mortar, curing, making of masonry platform for unloading the wet mix/ paste, embedding the fittings/fixtures including providing PCC 1:2:4 (M15) etc, all as specified for all heights and depths. Deduction for rectangular or circular openings shall be done as per relevant BIS Codes.

6.1.1 Payment for brick masonry works of one or more brick thickness, including circular brickwork, shall be made on cubic metre basis of the work done.

6.1.2 Payment for half brick masonry work shall be made on square metre basis on the area of work done and shall also include the cost of supplying and fixing of reinforcement bars in position.

6.1.3 Payment for forming the cavity shall be in square metres and shall include the cost of laying of bitumen coated tor steel ties in position, labour required for keeping the cavity clear, providing air slots etc.

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मानक विनिर्देशन

सिविल एवं संरचनात्मक कार्य

STANDARD SPECIFICATION
CIVIL & STRUCTURAL WORKS

गिराने एवं तोडने सम्बंधी कार्य

DEMOLITION AND DISMANTLING

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor		Standards Bureau Chairman
					Approved by		
6	03.04.25	REAFFIRMED & REISSUED	AD	MM	AS		MN
5	13.05.19	REAFFIRMED & REISSUED	TK	AS	RS		RKT
4	18.11.13	REVISED & ISSUED AS STANDARD SPECIFICATION	AJS	RS	PKM	SC	SC
3	10.06.08	REAFFIRMED & REISSUED	PKB	PKM	VK		VC
2	25.04.01	REVISED & ISSUED AS STANDARD SPECIFICATION	SKP	RS	SCJ		MI
1	16.03.98	REVISED & ISSUED AS STANDARD SPECIFICATION	SARITA	SKP	SCJ		AS
0	AUG'89	ISSUED AS STANDARD SPECIFICATION		AKV	GPL		RCPC

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Abbreviations:

C&D	:	Construction & Demolition
GI	:	Galvanized Iron
RA	:	Recycled Aggregates
RCC	:	Reinforced Cement Concrete
PCC	:	Plain Cement Concrete

Structural Standards Committee

Convenor : Mr. Anurag Sinha

Members : Mr. Virender Goel
Mr. Deepak Agrawal
Mr. VK Panwar
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CONTENTS

1.0 SCOPE 4
2.0 GENERAL 4
3.0 SAFETY PRECAUTIONS 4
4.0 PROCEDURE 5
5.0 CLEANING & STACKING 5
6.0 DISPOSAL 5
7.0 C&D WASTE MANAGEMENT 6
8.0 PAYMENT 6

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1.0 SCOPE

This specification covers the procedure and safety requirements for demolition and dismantling of masonry (Brick & Stone), concrete (Plain /Reinforced), structural steel (covered/ open) works.

2.0 GENERAL

2.1 Apart from this specification, the demolition and dismantling of structures (part or whole) shall be in compliance with all statutory safety regulations and any other special requirement as shown/ noted on the drawings and General Conditions of Contract. Prior consent and approval of the Engineer-in-Charge shall be obtained in writing before starting any dismantling works. Any restrictions imposed regarding working hours shall also be strictly followed by the Contractor.

2.2 All materials obtained from dismantling/demolition operations shall be the property of the Owner unless otherwise specified and shall be segregated as serviceable or unserviceable materials and kept in safe custody until handed over to the Engineer-in-Charge.

2.3 Contractor shall follow the principle of selective demolition by sequencing the demolition activities in such a way that the non-structural materials like window/ door frames, pipes, tiles, bricks, asphalt, ceramics, etc. shall be removed first before starting the main demolition activities.

2.4 Where it becomes necessary to disconnect any existing service line(s) (such as electrical, piping etc.) during dismantling/demolishing operation and where so required by the Engineer-in-Charge, suitable alternate arrangement shall be made by the Contractor to maintain the continuity and proper functioning of the affected service line(s) with the approval of the Engineer-in-Charge at no extra cost to the Owner.

2.5 Specification No. 6-68-0003 (Earthwork) shall be referred to the extent applicable.

3.0 SAFETY PRECAUTIONS

3.1 The Contractor shall adhere to safe demolishing/ dismantling practice at all stages of work to guard against accidents, hazardous and unsafe working procedures.

3.2 Necessary propping, shoring, strutting and/or underpinning shall be done for the safety of all surrounding structures (whose safety is likely to be endangered) before taking up the demolishing and dismantling works.

3.3 Temporary enclosures/ barricading made out of GI sheets, fencings, danger lights, warning tapes, etc. shall be provided by the Contractor and got approved by the Engineer-in-Charge before start of work to prevent accidents.

3.4 Contractor must ensure the availability of adequate fire fighting equipments/ arrangements before starting actual demolishing/ dismantling works. These facilities shall be made available throughout the entire operation of demolition and dismantling of structures.

3.5 All equipments, pipes, fittings and instruments, underground utilities etc. located in the vicinity shall be protected by suitable means, as decided by the Engineer-in-Charge, during demolishing/ dismantling operations.

3.6 Roads and working spaces shall be kept free of any debris/dismantled materials at the end of day's work.

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3.7 Necessary measures shall be taken to keep the dust and noise nuisance to minimum levels.

3.8 Dismantled elements/components shall not be dropped from a height or thrown from a distance. Dismantling of elements fixed by screws/bolts/hooks etc. shall be done by taking out the fixtures with proper tools only. Such fixtures may be allowed to be cut by sawing or flame cutting, in the event of their being stuck up due to corrosion etc. However, the decision of Engineer-in-Charge in this regard shall be final and binding. Welds shall be removed by flame cutting. Tearing or ripping of elements shall not be resorted to under any condition.

3.9 Dismantling of equipments/ instruments and such other fixtures shall be done with utmost care with proper tools & tackles and shall be stacked separately. Their disposal or retainment shall be as per the directions of Engineer-in-Charge.

4.0 PROCEDURE

4.1 Entire work of demolishing & dismantling shall be meticulously planned. Prior to start of work, the Contractor shall thoroughly understand the scope and nature of the work, and then prepare and submit the proposed work execution plan of demolishing & dismantling to the Engineer-in-Charge for his review. Comments if any, shall be taken care by the contractor and execution of the work shall be done based on the revised execution plan.

4.2 Demolition and dismantling shall be restricted to the extent shown on drawings or as directed by the Engineer-in-Charge.

4.3 Necessary work permits (as applicable) shall be obtained prior to start of demolishing/ dismantling activities.

4.4 Demolition of any structure shall be carried out in the sequence reverse to that followed at the time of its construction.

4.5 Dismantling shall be done in a systematic manner. All elements including equipments/ instruments shall be carefully removed without causing any damage.

4.6 Blasting in any form shall not be permitted. However, techniques like pneumatic/ hydraulic breakers, diamond cutting, etc. shall be utilized to the maximum possible extent.

4.7 Chipping of concrete/grout shall be done with precision by chiseling. The finished surfaces shall be made true to the requisite size and shape.

4.8 Pockets/holes of specified size shall be made/ cut by drilling/ chiseling/ core cutting/ diamond cutting, etc.

4.9 Cut-outs in RCC Slab/ wall shall be made by vibration-less spark-free mechanical means like core-cutting, wet cutting by diamond wall saw system, etc.

5.0 CLEANING & STACKING

All demolished/dismantled serviceable materials such as bricks, stones, reinforcement bars, structural steel, sheeting etc. shall be separated out, cleaned and stacked in separate lots within the plant boundary as directed by the Engineer-in-Charge.

6.0 DISPOSAL

All unserviceable materials shall be disposed off in spoil heaps within or outside the plant boundary as per the directions of the Engineer-in-Charge. Areas required outside the plant boundary for dumping of disposed material shall be arranged by the contractor and got approved by the Engineer-in-Charge.

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7.0 C&D WASTE MANAGEMENT

Contractor shall make all possible efforts to reduce, reuse and recycle Construction & Demolition (C&D) waste. A comprehensive Waste Management Plan shall be submitted to the Engineer-in-Charge for review. As a social responsibility, contractor shall promote and spread awareness about recycling of C&D waste that can act as a perfect substitute for depleting natural aggregate resources, shortage of dumping sites, increasing transportation & disposal cost, stringent regulations for extracting new materials and environmental pollution as a whole. Recycling equipments like jaw/ cone crushers, shaft impactors, magnetic separators, vibrating screens, washing equipments, etc. are now easily available in the market. Recycled Aggregates (RA) both coarse & fine can be used in PCC, pavements, drains, plastering, making bricks, kerb stones, pavement blocks and for soil stabilization. Residual concrete can be recycled in Ready Mixed Concrete Plants by installing Recycling Drum and rebars extracted from C&D waste can be used in drains, pavements, chairs, spacers, stirrups, etc.

8.0 PAYMENT

8.1 General

Measurement of all works shall be taken prior to start of demolishing/ chipping/ dismantling works.

8.2 Masonry/Concrete Works (Demolition)

8.2.1 Payment shall be made on the basis of actual volume in cubic metres (cu.m.) of masonry/ concrete works demolished. The thickness of plaster/ bitumen felt shall be included in measurements.

8.2.2 The rate for demolishing shall include supply of all labour, tools & tackles, necessary safety measures, propping, underpinning, scaffolding, handling, cutting, straightening, scraping & cleaning of reinforcement bars and other embedments (in case of reinforced concrete works), sorting out and stacking of all serviceable materials, disposal of all unserviceable material, clearing the site, etc. all complete as specified and directed by the Engineer-in-Charge.

8.3 Excavation & Backfilling

8.3.1 Excavation and backfilling shall be paid separately as per relevant clauses of Specification No. 6-68-0003 for Earth Work.

8.4 Chipping of Concrete Works

8.4.1 Payment shall be made on the basis of admissible area in square metres (sq.m.) of concrete surfaces chipped, pertaining to the different categories of thicknesses specified in the schedule of items.

8.4.2 The rate for chipping shall include supply of all labour, tools and tackles, necessary safety measures, scaffolding, chiseling, handling, exposing, cutting, straightening, scraping, clearing the reinforcement bars (in case of reinforced concrete works), wire brushing and washing the exposed surfaces, disposal of all unserviceable material etc. all complete as directed.

8.5 Making Pockets/Holes in Concrete Works and Cut-outs in RCC Slab/ Wall

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8.5.1 Payment for Pockets/ holes shall be made on the basis of number (Each) of pockets/ holes of sizes upto & inclusive of 200x200x500mm deep, made or cut in the concrete works at all depths & heights.

8.5.2 Payment for cut-outs in RCC slab/ wall shall be made in CuM on the basis of plan/ elevation area for a thickness upto & inclusive of 400mm at all depths & heights.

8.5.3 The rate for making pockets/holes and cut-outs shall include supply of all labour, tools & tackles, necessary safety measures, scaffolding, chiseling, drilling, core/ diamond cutting, diamond wall saw system, handling, cutting or relocating reinforcement bars, cleaning, disposal of all unserviceable material etc. all complete as directed.

8.6 Dismantling of Structural Steel Works

8.6.1 Payment shall be made on the basis of weight (MT) of the structure/components being dismantled. Assessment of weight shall be done as per the specifications or as per the direction of Engineer-in-Charge.

8.6.2 The rate for dismantling shall include supply of all labour, tools and tackles, equipment, consumables, necessary safety measures, scaffolding, propping, handling, unbolting, cutting (by sawing or flame cutting) of gussets/ plates/ bolts/ hooks/ welds, cleaning, sorting out and stacking of all serviceable materials, disposal of all unserviceable material, etc. all complete as specified and directed.

8.7 Dismantling of Roof & Wall Sheeting

8.7.1 Payment shall be made on the basis of dismantled sheeted area in square metres (sq.m.) of plan area in case of roof sheeting and area in elevation in case of side and louver sheeting.

8.7.2 The rate for dismantling shall include supply of all labour, tools and tackles, equipments, consumables, necessary safety measures, handling, scaffolding, unbolting, cutting (by saw or flame cutting) of hook bolts, removal of ridges, gutters, flashings, transporting, stacking of all serviceable materials, disposal of all unserviceable material, etc. all complete as directed.

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सिविल एवं संरचनात्मक कार्य
विविध मदें

STANDARD SPECIFICATIONS
CIVIL AND STRUCTURAL WORKS
MISCELLANEOUS ITEMS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
6	13.03.25	REVISED & REISSUED	TARUN KAPOOR	AMARJEET	ANURAG SINHA	MAINAK NANDI
5	24.01.22	REVISED & REISSUED	TARUN	AMARJEET	ANURAG SINHA	S.MAZUMDAR
4	22.03.16	REVISED & REISSUED	MODITA	ALPANA	R.SRIVASTAVA	S.CHANDA
3	29.06.10	REISSUED	AS	PKM	SCH	N DUARI
2	26.04.01	UPDATED & REISSUED	SBJ	R SOOD	SC JAIN	MI
1	AUG 94	UPDATED & REISSUED	SBJ	R SOOD	GPL	A SONI
0	AUG 89	ISSUED AS STANDARD SPECIFICATION	-	AKV	GPL2	RCPC

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Abbreviations:

BIS	:	Bureau of Indian Standards
DPC	:	Damp Proof Course
FGL	:	Finished Ground Level
IS	:	Indian Standard
RCC	:	Reinforced Cement Concrete

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CONTENTS

1.0 SCOPE 4
2.0 REFERENCES 4
3.0 MATERIALS 4
4.0 GENERAL REQUIREMENTS 4
5.0 PRE-CONSTRUCTIONAL ANTI-TERMITE TREATMENT 4
6.0 ANTI-CORROSIVE LAYER 6
7.0 DRESSING & TRIMMING 7
8.0 BREAKING PILE HEADS 7
9.0 BUILDING-UP PILE HEADS 7
10.0 HARD CORE 8
11.0 SAND FILLING IN PLINTH/FOUNDATIONS 9
12.0 DAMP PROOF COURSE (DPC) 9

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1.0 SCOPE

The scope shall be as specified separately for different items below.

2.0 REFERENCES

2.1 BIS Codes

IS:73 : Paving bitumen - specification

IS:383 : Specification for coarse and fine aggregates from natural sources for Concrete

IS:6313 : Code of practice for Anti-termite measures in buildings

2.2 EIL specifications

6-68-0002: Materials
6-68-0004: Plain and Reinforced Cement Concrete

3.0 MATERIALS

The materials shall be as specified separately for different items below.

4.0 GENERAL REQUIREMENTS

The Contractor shall test the materials, wherever applicable, in approved laboratory as required by the Engineer-in-Charge and furnish test certificates for materials and obtain the approval of the Engineer-in-Charge prior to the use of such materials in the works. All tests shall be in accordance with relevant Indian Standards.

5.0 PRE-CONSTRUCTIONAL ANTI-TERMITE TREATMENT

5.1 Scope

This specification establishes the materials and method of accomplishing pre-constructional anti-termite treatment of soil for protection of buildings against attack by subterranean termites with the usage of chemical emulsions in accordance with the procedure laid down.

5.2 Materials

Refer EIL Specification No. 6-68-0002.

5.3 Procedure for Treatment

5.3.1 Anti-termite chemicals have an adverse effect upon health when absorbed through the skin, inhaled as vapours or spray mist or swallowed. Applicators shall wear appropriate Personal Protective Equipments (PPEs) and exercise due precautions in handling these chemicals while preparing solution and carrying out soil treatment.

The storage and application of anti-termite compounds shall be carried out by a trained professional agency possesses a valid license issued by the respective State/ Central government department of Agriculture as required under the Insecticides Act and the Rules framed thereunder. Necessary documents shall be submitted by the Contractor to the Engineer-in-Charge for review and approval.

Apart from this specification, the work shall be carried out in compliance with IS:6313. In case of any contradiction, this specification shall govern.

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5.3.2 **Site Preparation**

Prior to start of Anti Termite treatment, area(s) shall be made free from logs, stumps, timber offcuts, leveling pegs, roots of plants/ trees etc. Soil treatment shall start when foundation trenches/ pits are ready to take concrete/ masonry in foundations and plinth area ready for laying the subgrade. Treatment shall not be carried out when it is raining or the subsoil water level is at the same or higher than the level of treatment. In the event of water-logging of foundations, the water shall be pumped out and the chemical emulsion applied when the soil is absorbent.

5.3.3 **Treatment of the excavated pits/ trenches and backfill for Foundations**

a) The bottom surface and the lower 300 mm side surfaces of the excavated pits/ trenches for foundations of masonry works and RCC plinth beams supporting such masonry works, shall be treated with specified chemical emulsion @ 5 litres/m^2 of the surface area. However, no such treatment shall be required in case of pits/ trenches made for RCC foundations supporting RCC walls and/ or columns.

b) On completion of construction of masonry foundations, the backfill in immediate contact with the substructure shall be treated in layers, of 300 mm, with emulsion @ 7.5 litres/m^2 of the vertical surface of the substructure (i.e. 7.5 x 0.3 = 2.25 litres/meter of perimeter) for each side. The treatment shall be given after ramming of each layer of soil, by rodding the earth at 150 mm centres close to the wall surface and working the rod backward and forward (parallel to the wall surface) and then spraying the specified dosage of emulsion. The emulsion shall be directed towards the masonry surfaces so that the soil in contact with these surfaces is well treated with the chemical. After the treatment, the soil shall be tamped back into place. This shall be done for full depth of the fill.

c) For RCC walls and columns, the treatment as specified in (b) shall start from a depth 500 mm below the finished ground level, and shall be done upto the FGL.

5.3.4 **Treatment of Plinth/ Basement and Apron**

a) The top surface of the consolidated earth below the non-suspended floor slabs and the peripheral aprons of widths upto 750 mm, the bottom surface and side surfaces of the excavated pits for the basements shall be treated with chemical emulsion @ 5 litres/m^2 of the surface area. Holes 50 mm to 75 mm deep at 150 mm centre, both ways, shall be made on the surface with 12 mm diameter mild steel rod and then emulsion shall be sprayed uniformly over the area. At expansion joint locations, anti-termite treatment shall be supplemented by treating through the expansion joint @ 2.0 litres per linear metre of joint after the sub-grade has been laid.

b) Treatment of Junctions of plinth filling and wall/column faces shall be done after making a small channel 30 mm x 30 mm, by making rod holes 150 mm apart (upto the ground level) in the channel and then by moving the rod backward and forward to break up the earth. The chemical emulsion shall be poured along the channel @ 7.5 litres/m^2 of the vertical wall/column surface so as to soak the soil right to the bottom. The soil shall be tamped back into place after the treatment.

5.3.5 **Treatment of Soil along External Perimeter of Building**

After the building is complete, the earth along the external perimeter shall be rodded at intervals of 150 mm and to depth of 300 mm. The rod shall be moved backward and forward parallel to the wall to break up the earth and chemical emulsion poured along the

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wall @ 7.5 litres/m^2 of vertical surface (i.e. 7.5 x 0.3 = 2.25 litres/metre of perimeter). After the treatment, the earth shall be tamped back into place.

5.4 Guarantee

A Guarantee of minimum 10 years shall be provided by the contractor against the performance of the Anti-termite treatment.

5.5 Payment

This clause shall apply to Item Rate tender only.

Payment for pre-constructional anti-termite treatment shall be made on square metre (sq.m.) basis of plinth area of the building at ground floor only.

The rate shall include supplying all materials, spray pumps, tools, tackles & other accessories, labour, site preparation, rodding, tamping, mixing, spraying the specified chemical emulsion at prescribed dosage, storage facilities, handling, transporting etc. all complete as directed & specified.

6.0 ANTI-CORROSIVE LAYER

6.1 Scope

This specification covers the requirement of materials, method of preparation and procedure for laying an anticorrosive layer over top surface of tank foundations for protection of bottom plates of steel tanks against corrosion attack.

6.2 Materials

6.2.1 Sand shall be clean, dry, coarse, hard, angular, free from coatings of clay, dust and mix of vegetable and organic matter and shall conform to IS:383 - Grade III.

6.2.2 Bitumen shall be of grade VG10 conforming to IS:73.

6.3 Mixing and Laying

The bitumen shall be heated till it melts. 3% kerosene may be added if required. Sand shall be thoroughly mixed with bitumen (8% to 10% by volume) in a mixing drum to give a uniform mixture and shall be laid over clean and dry surface of tank foundation to line, grade and levels as shown on the drawings and directed by the Engineer-in-Charge. Bitumen shall not be heated beyond the specified temperature limits. The layer shall be tamped to form hard mass of specified compacted thickness.

6.4 Payment

This clause shall apply to Item Rate tender only.

The payment shall be made on square metre (sq.m.) basis of the area covered with the anticorrosive layer.

The rate shall include supplying all materials, tools, plants, labour, transportation, handling, heating, mixing, laying, tamping etc. all complete as specified.

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7.0 DRESSING & TRIMMING

7.1 Scope

This specification covers the procedure for dressing, trimming and paving with earth the peripheral area around the completed building/ structure.

7.2 Procedure

The ground all around the completed building/structure for 3 metres width or as specified by the Engineer-in-Charge, shall be cleaned and dressed to suitable slope. Over the prepared ground a layer of approved earth shall be spread, watered and well consolidated so as to achieve an average thickness of 75 mm.

7.3 Payment

This clause shall apply to Item Rate tender only.

Payment shall be made on square metre (sq.m.) basis of the actual area dressed and paved with earth.

The rate shall include supplying all materials, labour including cleaning, dressing the ground to required slope, spreading of earth, watering, ramming, consolidating etc. all complete as directed.

8.0 BREAKING PILE HEADS

8.1 Scope

This specification covers procedure for breaking pile heads of RCC piles.

8.2 Procedure

8.2.1 Head of already cast/ driven RCC piles shall be broken after 28 days of casting up to a length and elevation as shown on the drawing by chiseling or by approved mechanical means taking all necessary safety precautions. Care shall be taken that pile reinforcement is not cut or damaged during chiseling operation. All debris and loose or cracked concrete in the pile shall be removed and disposed off within the plant boundary as per the directions of the Engineer-in-Charge and site shall be left clean for casting of pile caps. The surface of reinforcement bars shall be cleaned, if required by wire brushing, so that no old concrete sticks to them.

8.3 Payment

This clause shall apply to Item Rate tender only.

Payment shall be made per pile basis for the actual number of pile heads broken.

The rate shall include supplying all tools and tackles, labour including disposal of debris, bending the pile reinforcements for proper anchorage within the pile cap etc. all complete as directed.

9.0 BUILDING-UP PILE HEADS

9.1 Scope

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This specification covers requirements of materials and procedure for building-up of RCC Pile Heads.

9.2 Materials

9.2.1 Concrete shall be of the same grade & EIL specification shall be same as that for the pile.

9.2.2 Reinforcement shall be of the same grade as that for the pile.

9.2.3 Type of cement shall be same as that used for the pile.

9.3 Procedure

Concrete in existing piles shall be chiseled off minimum upto the lap-length of the reinforcements in the pile. In cases where reinforcements are longer than the concreted piles, the top concrete of the existing piles shall be chiseled or by approved mechanical means upto a length of 800 mm.

Concrete surface and reinforcement of pile shall be cleaned of any dirt, grease, debris etc. and concrete surface shall be made rough by hacking. Reinforcement shall be lapped/ welded as per the direction of the Engineer-in-Charge. Neat cement slurry shall be applied on top surface of concrete and using approved formwork, concreting shall be done upto the level shown on the drawing and as directed by the Engineer-in-Charge.

9.4 Payment

This clause shall apply to Item Rate tender only.

Payment shall be made on cubic metre basis for the total quantity of concrete actually poured for achieving the level as shown on drawings.

The rate shall include supply of all materials (except reinforcement which shall be paid separately as per respective item) labour, cleaning, welding, shuttering, vibrating, finishing, curing etc. all complete. Cutting of pile heads and excavation including backfilling shall be paid separately as per respective item.

10.0 HARD CORE

10.1 Scope

This specification covers the requirements of materials and procedure for laying of hard core.

10.2 Materials

Hard core shall consist of broken/ crushed stones of 150 mm and down size. Stones shall be sound, angular, hard and free from flakes, dust and other impurities.

10.3 Procedure

Hard core shall be laid to the grade, level and thickness as shown on the drawing. Broken stones of required height shall be vertically placed and blinded with approved murrum/ sand and consolidated with roller including watering, dressing etc. However, areas inaccessible by roller may be compacted by hand rammer.

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10.4 Payment

This clause shall apply to Item Rate tender only.

The hard core shall be measured on the basis of volume in cubic metres (cu.m.) of the compacted hard core laid. The rate shall include all labour, materials, consolidation by rammer/ roller, watering, dressing etc. all complete.

11.0 SAND FILLING IN PLINTH/FOUNDATIONS

11.1 For specification of sand to be used for filling, reference shall be made to EIL Specification No. 6-68-0002.

11.2 Filling shall be carried out in layers not exceeding 150 mm and shall be compacted mechanically or by saturation to specified grade and level and to obtain 90% laboratory maximum dry density or as specified in schedule of rates.

11.3 Compaction by flooding may be accepted at the discretion of the Engineer-in-Charge, provided the required compaction is achieved.

11.4 The Contractor shall not commence filling in and around any work until it has been permitted by the Engineer-in-Charge.

11.5 Payment

This clause shall apply to Item Rate tender only.

Payment shall be made on cubic metre (cu.m.) basis of the finished compact volume. The rate shall include cost of sand for any compacted thickness, wastage if any, all handling, transport for all leads, tamping, watering, flooding, dressing etc. Any brick work required for ponding shall be paid separately under relevant item.

12.0 DAMP PROOF COURSE - (DPC)

12.1 All materials used for Damp Proof Course shall comply with EIL Specification No. 6-68-0002.

12.2 The 40 mm thick Damp Proof Course shall consist of plain cement concrete of minimum grade M20 (Nominal mix) with 10mm down aggregates.

12.3 Integral water proofing compound of approved make, conforming to IS:2645, shall be mixed with concrete as per manufacturer's specification.

12.4 The Damp Proof Course shall be laid at plinth level of masonry walls, flush with the floor surface and shall not be carried across doorways.

12.5 Before laying, the top surface of wall shall be thoroughly cleaned and watered. The DPC layer of 40mm thick shall be laid, retaining the edges vertical by necessary formwork and shall be well tamped and troweled to smooth finish. The layer shall be cured by keeping the surface wet for 40 hours and after it has dried, two coats of hot bitumen of grade VG10 conforming to IS:73 shall be applied over it at the rate of 1.7 kg/sqm for each coat. Over the layer of hot bitumen, dry sharp sand shall be sprinkled evenly before hardening of top coat of bitumen paint.

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12.6 Payment

This clause shall apply to Item Rate tender only.

Payment shall be made on square metre (sq.m.) basis of the area laid with plain cement concrete. The rate shall be inclusive of formwork, providing and mixing Integral water proofing compound, curing, providing and laying bitumen, supplying and spreading sand over bitumen etc. all complete.

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मानक विनिर्देशन
सिविल एवं संरचनात्मक कार्य

बाईपोलर कंक्रीट अंतर्वेशित क्षारण अंतर्अधिमिश्रण

STANDARD SPECIFICATION
CIVIL & STRUCTURAL WORKS

BIPOLAR CONCRETE PENETRATING CORROSION INHIBITING ADMIXTURE

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
2	21.07.2025	UPDATED AND ISSUED AS STANDARD SPECIFICATION	AV	RM/SP	AS	MN
1	18.06.2019	UPDATED AND REISSUED	TK	AJS	RS	RKT
0	26.04.2012	ISSUED AS STANDARD SPECIFICATION	AJS	PKM	SC	DM

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ABBREVIATIONS:

AASHTO	:	American Association of State Highway and Transportation Officials
ASTM	:	American Society for Testing & Materials
CPCIA	:	Concrete Penetrating Corrosion Inhibiting Admixture
IS	:	Indian Standard
JIS	:	Japanese Industrial Standard
OPC	:	Ordinary Portland Cement
PPC	:	Portland Pozzolana Cement
PSC	:	Portland Slag Cement
SRC	:	Sulphate Resistant Cement

Structural Standards Committee:

Convener: Mr. Anurag Sinha

Members:
Mr. Virender Goel
Mr. Deepak Agrawal
Ms Alpana Srivastava
Dr. Sudip Paul
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Mr. Indrajit Neog (Construction)
Ms Papia Mandal
Mr. Vikram Kumar Gupta

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CONTENTS

1.0 SCOPE 4

2.0 REFERENCES 4

3.0 SAMPLING 4

4.0 TESTING REQUIREMENTS 4

5.0 HEALTH, SAFETY & ENVIRONMENT CONSIDERATIONS 5

6.0 PACKAGING 5

ANNEXURE-A (SHORT TERM TESTS) 6

ANNEXURE-B (LONG TERM TESTS) 7

APPENDIX-I (MODIFIED ACCELERATED CORROSION TEST) 9

APPENDIX-II (OPEN CIRCUIT POTENTIAL Ecorr TEST) 10

APPENDIX-III (REDUCTION IN CORROSION CURRENT Icorr TEST……..…..……12

APPENDIX-IV (IMMERSION TEST)……15

APPENDIX-V (TEST FOR EFFECT ON COMPRESSIVE STRENGTH WITH CPCIA)….16

APPENDIX-VI (ELECTROCHEMICAL POLARIZATION TEST) 17

APPENDIX-VII (CORROSION TEST) 18

APPENDIX-VIII (CHLORIDE ION PENETRATION TEST) 19

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1.0 SCOPE

This specification prescribes the requirements and test methods including performance test for evaluating the efficiency of Bipolar Concrete Penetrating Corrosion Inhibiting Admixture (CPCIA) for protecting steel reinforcement embedded in concrete from corrosion. Non-concrete penetrating, Nitrite & Nitrate corrosion inhibitors are excluded from the scope.

2.0 REFERENCES

2.1 Codes

ASTM G1-03, ASTM G3-14, ASTM G109, ASTM G180-04, ASTM C1202, JIS Z-1535, AASHTO T259, IS 2, IS 101(Part1/Sec.5), IS 456, IS 1202, IS 1448, IS 1786, IS 9103, etc.

2.2 EIL Specifications

6-68-0001 : General Scope
6-68-0002 : Materials

3.0 SAMPLING

3.1 The representative samples of the material shall be drawn as per the table given below:

No. of containers (Lot)	No. of containers to be selected for sampling (N)
Up to 50	1
51-100	2
101-300	3
301-500	4
501& Above	5 Plus 1 for every lot of 300 containers

4.0 TESTING REQUIREMENTS

4.1 The product shall comply with the requirements specified in Annexure-A (Short Term Tests) and Annexure-B (Long Term Tests). Both the tests shall be conducted in an approved laboratory.

4.2 Unless specified otherwise, all the tests under Indian tropical conditions shall be conducted at room temperature 27 ± 2°C and relative humidity at 65 ± 5 % in a well ventilated chamber free from dust.

4.3 The contractor shall select the product from EIL approved vendor list and submit the Manufacturer Test Certificate to the Engineer-in-Charge. Approval for usage of product shall be given after satisfactory Short Term test results. Long Term tests are not mandatory for the products listed in EIL approved vendor list.

If the product is not from an EIL approved vendor, both Short term as well as Long term tests are mandatory. The contractor shall submit the Manufacturer Test Certificate to the Engineer-in-Charge and approval for usage of product shall be given after satisfactory Short Term test results. However, payment shall be released after the product complies with the requirements of Long Term test results.

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5.0 HEALTH, SAFETY & ENVIRONMENT CONSIDERATIONS

5.1 The CPCIA shall not cause harm to applicators by mean of inhalation or skin contact. All precautionary measures shall be prescribed by the manufacturers along with instructions of usage. Application methodology shall be approved by the Engineer-in-Charge.

5.2 The waste shall be discharged in accordance with applicable Environmental laws of land.

5.3 CPCIA shall not degrade or damage the construction materials like concrete, aggregates, steel reinforcement, formwork/shuttering.

6.0 PACKAGING

The product shall be supplied in air tight containers and following information shall be labeled on each container:

a) Name of the material
b) Name of the manufacturer
c) Volume/ weight of material
d) Specification number
e) Batch No. or Lot No. in bar code or otherwise
f) Month and year of manufacture
g) Ingredients & method of usage
h) Instructions for safe usage

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ANNEXURE-A

SHORT TERM TESTS

S. No .	Characteristics	Requirements	Methods of Tests
1.	Appearance	Brownish Liquid free from any visible residual deposits	Visually
2.	Odour	Mild Ammonical Odour	By smell
3.	Skin irritation	No irritation	By applying on reverse of the palm for 5 minutes.
4.	Ph i) As in supplied condition ii) 1% dilution ,w/w	 i) 9.0-12.0 ii) 9.0-12.0	 pH meter / Standard pH paper
5.	Specific Gravity at 27 ± 2ºC	1- 1.1	IS 1448
6.	Viscosity of the material as in supplied condition, by Ford cup No 4, at 27 ± 2ºC	10 - 20 sec.	IS 101(Pt.1/Sec.5)
7.	Accelerated Corrosion Test, for 21 hrs. i) Raw water without CPCIA ii) Raw water with CPCIA	 i) Excessive corrosion spots. ii) There shall not be more than 1-2 corrosion spots.	 Modified accelerated corrosion test based on Japanese standard JIS Z 1535 (Refer Appendix-I)
8.	Open circuit potential ECorr Test	Minimum shift in potential by 120 mV upon addition of CPCIA	Modified ASTM G 69 (Refer Appendix-II)
9.	Reduction in Corrosion Current ICorr	Minimum reduction by 15 times upon addition of CPCIA	Modified ASTM G 69 (Refer Appendix-III)
10.	Electrical resistivity (R)	R with CPCIA ≥ R without CPCIA	ASTM C1876

Notes:

a) Tests of Sr. Nos. 7, 8, and 9 shall be performed from supplied material received at the site and witnessed by the owner's representative or Engineer in Charge.

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ANNEXURE-B

LONG TERM TESTS
(Shall be performed in triplicate)

S. No .	Characteristics	Requirements		Methods of Tests
		Without CPCIA	With 1% CPCIA	
1.	Immersion test for 720 hrs. (Rebar weight loss method)	40.00 mpy, max.	2.00 mpy, max.	Immersion Test (Rebar weight loss test) as per ASTM G1-03 (Refer Appendix-IV)
2.	Effect of Concrete admixture on compressive strength	Concrete strength in sample with CPCIA* should be ≥concrete strength in sample without CPCIA*		Test for effect on compressive strength by addition of CPCIA as per IS 9103 (Refer Appendix-V)
3.	Polarization test by Tafel polarization with 3.5% Sodium Chloride, for 20 days: Rate of corrosion shall be	45 mpy, max.	9 mpy, max.	Electrochemical polarization test conducted on steel rebars embedded in concrete as per ASTM-G 3-14 & IS 9103 (Refer Appendix-VI)
4.	Effect of CPCIA* on corrosion of embedded steel rebars exposed to chloride environments after 09 cycles (14 days wetting and 14 days drying): Rate of corrosion shall be	25 Coulombs, max.	0.50 Coulombs, max.	Long term corrosion test as per ASTM G109 (Refer Appendix-VII)
5.	Chloride Migration profile properties of concrete (for all types of cements viz. OPC, PPC, PSC, SRC)			AASHTO T-259 (Refer Appendix-VIII)
	i) Chloride % in concrete at 30mm depth after 90 days.	0.025%, max.	Nil	Chloride ion penetration (Salt ponding test) as per IS 456
	ii) Ability to resist chloride ion penetration			
	a) Concrete grade M-30, Water cement ratio: 0.45	1650 Coulombs, max.	1000 Coulombs, max.	Electrical indication of concrete ability to resist Chloride Ion Penetration (Rapid Chloride Permeability test) as per ASTM C1202
	b) Concrete grade M-40, Water cement ratio: 0.40	1550 Coulombs, max.	1000 Coulombs, max.	

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6.	Initial screening of CPCIA for Steel in Concrete	Meeting criteria as described in point number 8, "Interpretation of Results"	ASTM G180-04

Notes:

a) CPCIA* : The CPCIA shall be used as 1% w/w of cement or as recommended by the manufacturer for conducting the tests mentioned in Annexure-B except Immersion test for 720 hrs. mentioned at S.No.1 where it shall be used as 1% w/w of water or as recommended by the manufacturer.

b) Rebars conforming to IS 1786 shall be used for testing purposes

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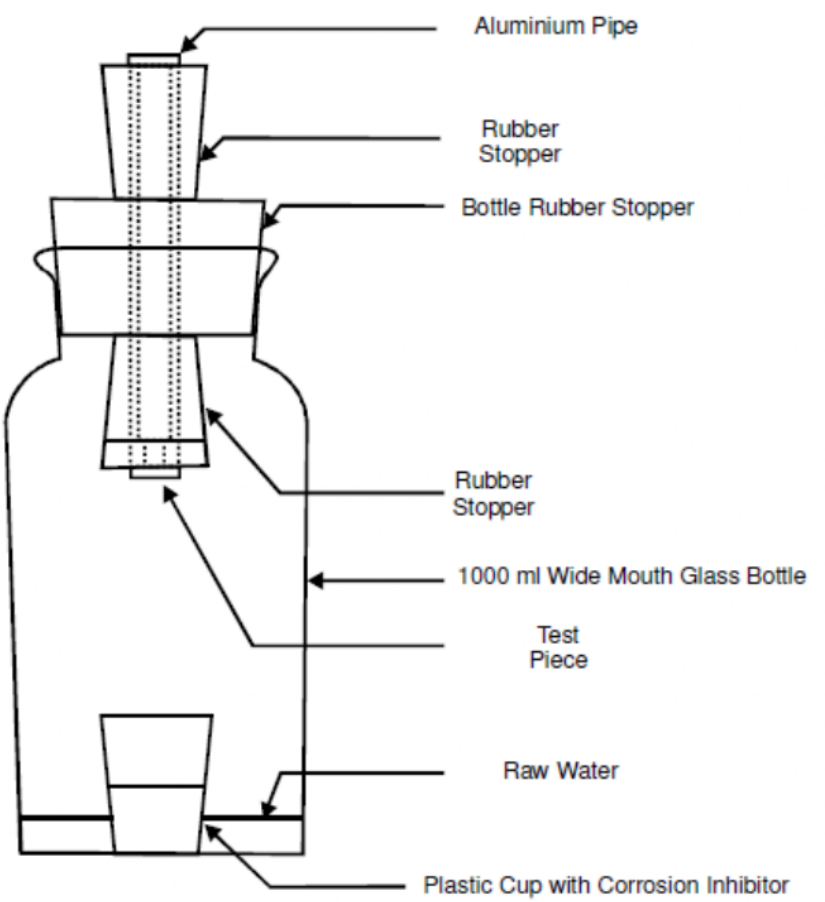
APPENDIX-I

MODIFIED ACCELERATED CORROSION TEST (BASED ON JAPANESE STANDARD JIS Z 1535)

TEST PROCEDURE

Attach steel test pieces conforming to IS 1786 (of size approx. 15mm dia and 12mm thickness drilled from one side c/c to a dia of 10mm and a depth of 10 mm to hold the Aluminium pipe) after thorough cleaning to white metal by using 1000 grade grit paper and subsequently polishing with 3/0 grade and finally with 4/0 grade grit paper to the Aluminium pipe with the help of cello tape so that it is firmly attached. The Aluminium pipe is then slid upwards till the test piece rests in the slot provided in the rubber cork, as shown in the figure.



Assembly with Corrosion Inhibitor

Pour 100 ml of tap water in both the bottles. Fill the plastic cup with 25 ml CPCIA solution as in supplied condition. In one of the bottles place the plastic cup with the CPCIA solution so that the cup is placed in the tap water. Allow to remain for 18 hours at ambient temperature. After 18 hrs. add chilled water having temperature below 1.0 ºC into the Aluminium pipes and allow to remain for 3 hrs. The temperature of the chilled water in the Aluminium pipes shall be maintained at 2.0 ± 0.5 ºC by frequently changing the chilled water with the help of the pipette. Observe the steel test pieces after the experiments i.e. 18+3=21 hrs., for any corrosion spots.

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APPENDIX-II

OPEN CIRCUIT POTENTIAL (Ecorr) TEST

This test is intended to show a live demonstration of the reduction in corrosion potential of steel under 3.5 % NaCl water with the addition of corrosion inhibitor.

Test Apparatus & Consumables

- **Working Electrode** : Polished TMT steel sample (dia. 15 ±2 mm) embedded in cast epoxy/ polymer
- **Reference Electrode** : Saturated Calomel Electrode (SCE) with KCl inserted
- **Voltmeter** : High Input resistance Digital Multimeter
- **Electrolyte Medium** : 3.5 % NaCl water solution 250 ml (Temperature 25-28^{0}C).
- **Water** : DM water or Potable water (Maximum TDS 200)
- **Salt** : Sodium chloride (lab grade) or table salt white powder
- **Test Temperature** : Ambient /At room temperature 23 to 35^{0}C

Sample Preparation

(a) Working Electrode : A working electrode shall be prepared by selecting proper available size of TMT/Carbon steel rebar, a desirable diameter is 16 mm or 20 mm, steel cutting & turning longitudinally on lathe machine to achieve desired shape & size as given in Fig.1. After that, a strong joint connection should be made by soldering or brazing a flexible, shielded and approximately 1 feet long copper wire to the steel disk over the round flat surface to achieve good electrical continuity. For masking this steel & joint connection, use a strong two-pack adhesive (polymer or epoxy system). Choose a proper size of mould and cast this probe attached steel by keeping it in the center of polymer as shown in Fig. 1. The sealed electrode should not leak from any side. Before proceeding to open circuit potential (OCP) testing, a good electrical continuity must be ensured between the exposed steel surface and the copper wire end by checking through a continuity tester or multimeter.

(b) Surface Polishing Preparation: The exposed surface of the mounted sample, the working electrode, should be polished very neatly and systematically up to the mirror finish level without any scratch marks. Follow the stepwise procedure for the preparation:

1. For polishing, keep emery paper horizontal on a clean & plain surface and start polishing with a coarser grade of emery paper 200 grit, or if necessary, start with 100 grit & use subsequent finer grades, i.e., 200, 300, 400,600, 800/1000, or 1200, & finally 02/04 grade.
2. Hold the sample tightly by hand & rub it on the exposed surface in full strokes in the forward direction and raise hand backward without rubbing on paper, similarly repeat the process until the complete grinding of the surface comes evenly in one direction.
3. To shift further to a finer grade turn the sample in perpendicular position (90 degrees) rather than previous direction & polish back and forth as in previous cycle. Continue this for subsequently every new paper and in addition to this before starting a new paper grade simultaneously wipe off surface with clean cloth or tissue paper using acetone / methanol solvent to remove any previous dirt picked up by the sample. Repeat the stepwise procedure systematically until a final mirror finish level is achieved without any scratch line mark.

Testing Procedure

1. Take a clean glass beaker of 500 ml capacity.
2. Fill the beaker with 3.5 % NaCl electrolyte water solution up to 250 ml.

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3. Prepare a working electrode of 15±2 mm dia. disk by cutting & grinding longitudinally TMT reinforced steel as per IS 1786 & solder it with a copper wire to edge of round section. It is completely bounded with epoxy/polymer casting, except the facing portion in exposed conditions. (refer Fig. 1a)
4. The exposed surface of steel must be hand polished with graded emery paper as explained in sample preparation.
5. Clean the polished surface with alcohol or any organic solvent & put the working electrode in the beaker containing the electrolyte solution.
6. For measuring E_{corr} of the polished steel surface in electrolyte solution, connect the other end (probe) of the copper wire to positive polarity of multimeter & turn the knob to the DC volt 2-5 mV range. Similarly connect the SCE banana pin to the –ve terminal of multimeter, after that immerse the SCE electrode near to exposed steel in the electrolyte solution up to the center of the exposed steel area (Refer figure 2), and ensure minimum gap between two electrodes.
7. Measure the reading. It must be more negative than -500 mV, or wait till it reaches between -500 to -550 mV (idle condition is >-550 mV w.r.t. SCE).
8. After showing Ecorr > -500 mV by multimeter, now add 2% of corrosion inhibitor by volume of the total electrolyte solution. Stir the solution slowly & wait up to 15-20 minutes.
9. The Ecorr of steel will shift towards the positive side as compared to the initial Ecorr without the addition of corrosion inhibitor (a minimum shift of -120 mV in Ecorr value is preferable for this test).

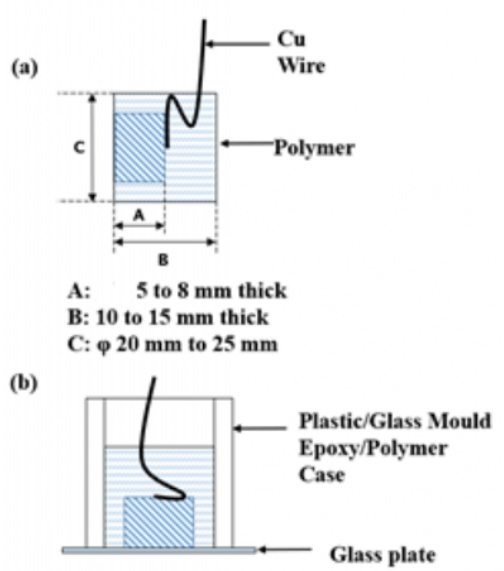

Figure 1.

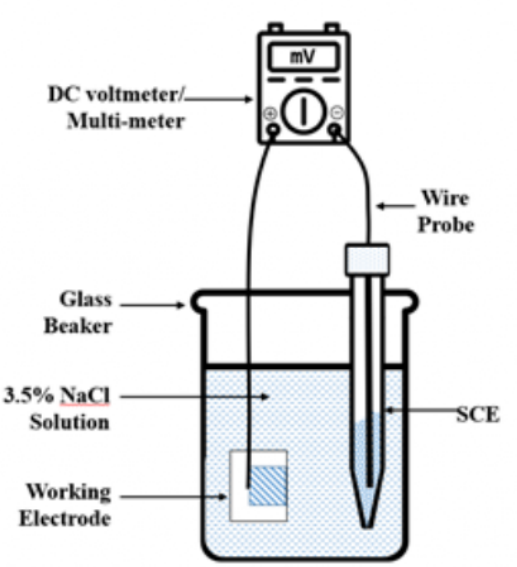

Figure 2.

Result Interpretation

Shifting of Ecorr towards the positive side by min. 120 mV clearly indicates that the corrosion inhibitor is capable of inhibiting corrosion, which displaces the corrosive ion away & chemically generates an invisible passive film on the steel surface when the corrosion inhibitor is added to the electrolyte solution.

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APPENDIX-III

INSTANT REDUCTION IN CORROSION CURRENT (I_{Corr}) AT FREE CORROSION POTENTIAL (E_{Corr}) ON SURFACE TREATED REINFORCED TMT/CARBON STEEL WITH CORROSION INHIBITOR

This test is intended to show a live demonstration of reduction in ongoing instant corrosion current when the surface attains near corrosion cell potential (E_{corr}), which is measured by SCE reference electrode of TMT/Carbon Steel under 3.5 % NaCl water solution with the addition of corrosion inhibitor. This is a short term electrochemical test which can be carried out easily in the laboratory to measure the quality and performance evaluation of corrosion inhibitor directly against TMT/Carbon steel rebar for the corrosion protection of steel in the concrete in a very short duration at ambient temperature.

Test Apparatus & Consumables

- **Working Electrode** : Surface finished TMT or Carbon steel rod sample (dia .10 mm to 16mm) treated with shot blasting or acid pickling (bright or silver finishing level)
- **Reference Electrode** : Saturated Calomel Electrode (SCE) with KCl inserted
- **Voltmeter** : High input resistance digital multimeter
- **Ammeter** : Very low resistance ammeter/ multimeter in DC micro and milliampere range
- **Counter Electrode** : Noble series metal (Nichrome/ Titanium/ SS 316 grade mesh)
- **Electrolyte Medium** : 3.5 % NaCl water solution 200 ml. (Temp. 25-28^{0}C).
- **Electrode support holder** : Non metallic or plastic disc having three hole around the disc
- **Water** : Clean potable water max. TDS 200
- **Salt** : Sodium chloride (lab grade) or table salt (white powder)
- **Test Temperature** : Ambient to 35 ^{0}C

Working electrode preparation

A surface treatment process like blasting or pickling should be carried out over the tempered martensite zone on the top of outer core surface of TMT rebar and it should be done completely free from rust & pit without any crevice marks or corrosion spots.

Since different surface treatment processes attributes significant variation in the corrosion potential and corrosion current of steel due to the intense degree of reaction taking place on the surface topography & profile across varying surface roughness as well as the rapid formation of active anodic and active cathodic cells on the metal surface when exposed to an electrolytic solution at a particular temperature, therefore the comparison shall be made between similar kinds of surface preparation treatments i.e. acid pickling, shot blasting, mechanical polishing or any other types in view to compare the inter and intra laboratory test results.

Counter electrode (CE): A counter electrode mesh made from a metal more noble than carbon steel must be used. The surface area of the CE should be at least 5 times or greater than that of the working electrode.

Testing Procedure

1. Take a clean glass beaker of 500 ml capacity.
2. Fill the beaker with 3.5 % NaCl electrolyte solution up to 350 ml.
3. Prepare the working electrode by selecting a suitable dia. of 12 mm TMT/reinforced steel up to 200 mm in length. The surface finish shall be prepared with fine shot blasting grit or acid pickling, & rinse with plenty of water prior to washing with alkaline solution.

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4. The treated surface area of steel, i.e. the area under test in the electrolyte must be cleaned thoroughly with an organic solvent (acetone/methanol or alcohol) before placing it in the chloride solution.
5. Place the cylindrical-shaped mesh as the counter electrode (SS 316 or superior metal mesh) inside the glass beaker by covering circumferential touching the beaker & shall be over around the test steel working electrode. For measuring corrosion current, extend a sufficient portion of the mesh outside the beaker for making contact with the ammeter probe.
6. Now insert the TMT steel working electrode in the centre of the beaker through a suitable nonmetallic support cover & again insert the calomel ref. electrode in between mesh & working electrode location through the nonmetallic support 12.5 mm hole.
7. First for measuring E_{corr} by using voltmeter connect the (+) polarity probe at top side of TMT steel rebar & connect banana socket pin adjoining calomel electrode to the (–) terminal of socket on voltmeter range and switch on the voltmeter by keeping the knob on the 2 or 5 DC mV range. Measure the reading, it must be more negative than -550 mV or wait till it reaches in between -550 to -625 mV (idle condition is around -600 mV w.r.t. SCE).
8. In the meantime, make connection ready for connecting DC ammeter probe, connect one terminal of the probe to the counter mesh electrode, and connect other end to the DC current socket on the ammeter through a toggle switch by keeping DC current on more than 10 mA range, the second end of probe shall be maintained in standby mode to connect directly to the working electrode when it is required. Keep watching the voltmeter reading, when it is showing around -600 mV (±10 mV), then note down the reading & immediately disconnect the TMT steel connection through the toggle switch connected with voltmeter & connect the ammeter probe to the TMT steel electrode promptly. Read out the current reading in mA range carefully and continuously. Note down the reading after 3 seconds time has elapsed right from the time of immediate connecting probe to the steel electrode. So, this current & voltage reading of TMT steel shall be considered the maximum value in 3.5 % chloride solution before the addition of the inhibitor.
9. Now add 3 % of bipolar corrosion inhibitor to the electrolyte solution & stir properly with a portable stirrer or spatula to mix the solution homogeneously. Disconnect the working electrode probe from the ammeter & connect it with the voltmeter probe. Continuously watch the E_{corr} reading, leave it in this position for 15 to 20 minutes. Finally, the E_{corr} reading will gradually decrease until maximum reduction is observed towards the positive side. At the moment when it reaches momentarily in stable condition and comes down to maximum 120 mV or more reduction in mV value versus previous E_{corr} reading then note down the final E_{corr} reading & disconnect the steel probe & immediately connect the ammeter probe to the steel electrode. Note down the current readings in microampere range after 3 seconds of visible reading at just moment of connecting probes as mentioned in point no. 8.

   To avoid jumbled wire connections & simplify the operation during testing a user can conduct this test in a more comfortable and simple way by using a SPDT switch board with a multiple probe connection setup.

Result Interpretation

The E_{corr} of steel will shift towards positive side as compared to initial E_{corr} without addition of corrosion inhibitor. The current (Icorr) will also reduce instantly, and the preferable value of reduction in current is minimum 15 times lower than the value without addition of corrosion inhibitor in the chloride solution.

Remark

Shifting of E_{corr} towards the positive side along with ongoing current which is falling rapidly, clearly indicates that the corrosion inhibitor is capable of inhibiting corrosion by displacing the corrosive ions away & chemically generating an invisible passive film on the steel surface when added to the electrolyte solution.

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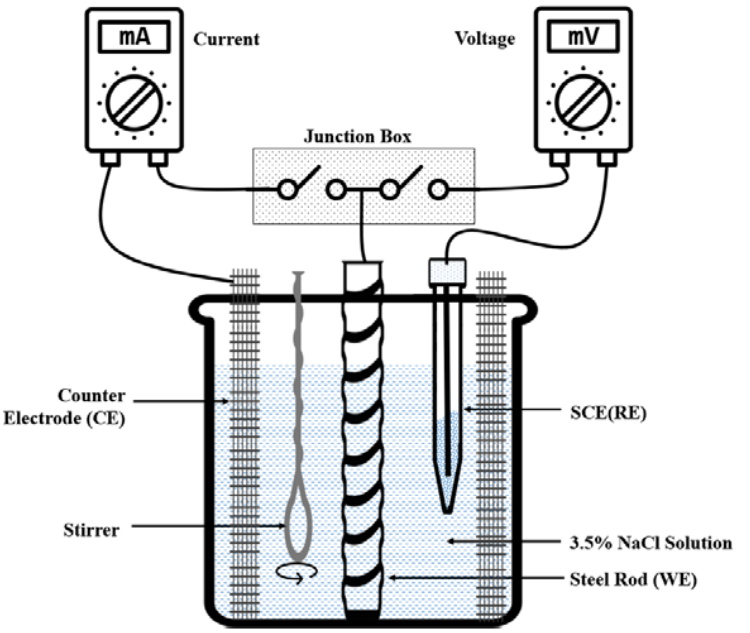

Pictures showing different surface treated TMT Steel reinforced bar

The results should include the following:

1. Type and size of rebar (diameter and length).

2. Types of surface treatment processes on steel in detail.

3. Max. E_{corr} & I_{corr} values just before the addition of the corrosion inhibitor.

4. Added dosage of corrosion inhibitor to the electrolytes.

5. Final values of reduced E_{corr} & I_{corr} measured after adding the bipolar corrosion inhibitor.

6. Lag time duration in seconds (waiting period in seconds) when taking corrosion current readings after switching on the ammeter.

7. Temperature of the electrolytic solution & the surrounding room temperature.

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APPENDIX-IV

IMMERSION TEST (REBAR WEIGHT LOSS TEST) (AS PER ASTM G 1)

TEST PROCEDURE

Take six pieces of Tor steel rebar conforming to IS 1786 of size approx. 40 mm length and 10 mm dia. Clean the rebar of any rust, mill scale etc., with the help of steel wire brush, till it has overall a shining surface. Now clean all the six pieces with solvent such as Benzene/Acetone to remove any loose rust /dust from the surface. Dry at 100 ± 2 ºC for 15 minutes in an oven. Cool and take the weights of all the six pieces and record it.

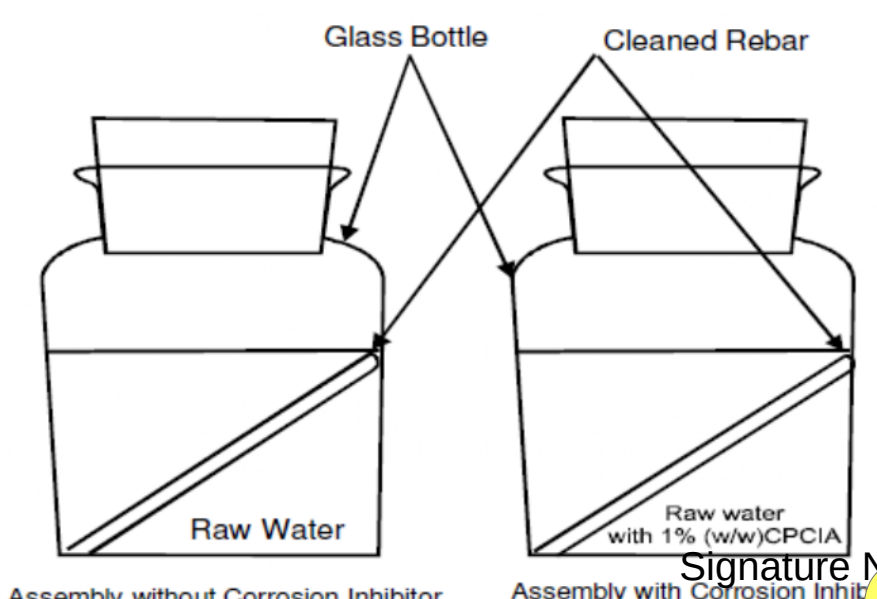
Take six transparent glass/plastic bottles of approx. 150±10 ml with air tight caps. Clean all the bottles with tap water and then fill them with 100 ml of tap water so that the bottles are approx. three fourth filled. In three of the six bottles, add CPCIA 1%, w/w or as recommended by the manufacturer of the water in the bottle. Now put one cleaned and weighed rebar test piece completely immersed in water/water + CPCIA, in all the six bottles and close the cap.

After 30 days (720 hrs.), take out all the six test pieces and put them in Clark solution (prepared by dissolving 20 gms. of Antimony Trioxide and 50 gms of Stannous Chloride in 1000 ml of Conc. Hydrochloric acid, S.G. 1.18) so that corrosion products are dissolved. After complete removal of corrosion products (in 5 minutes approximate), take out the test pieces and wash in running water and finally with distilled water. Then wash the test pieces, with solvent such as Benzene/Acetone. Dry at 100 ± 2 ºC for 30 minutes in an oven. Cool and take the weights of all the six pieces and record it.

Calculate the corrosion rate in mpy, by using the formula

Corrosion rate (mpy) = 534 (W1-W2) / DAT

Where W1-W2 is the weight loss in mg., D is the density of steel , A is the area in sq.inch and T is the time of exposure in hrs



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