

be installed as per I.S. 15105.

Pipe hangers shall be fixed on walls and ceiling by means of metallic rawl plugs.

Pipe supports in pump house shall be floor mounted and of mild steel / GI spacing of pipe supports shall not be more than that specified below: -

Nominal Pipe Size (mm)	Spacing (m.)
20 and 25	2.00
32 to 125	2.50
150 and above	3.00

Extra supports shall be provided at the bends and at heavy fittings like valves to avoid undue stress, on the pipes.

- 4.5** Vertical risers shall be parallel to walls and column lines and shall be straight and plumb. Risers passing from floor to floor shall be supported at each floor by clamps or collars attached to pipe and with a 12mm thick rubber pad or any other approved resilient material. Where pipes pass through the terrace floor, suitable curbing shall be provided to prevent water leakage. Risers shall also have a suitable concrete pipe support at the lowest point.
- 4.6** Pipe sleeves of diameter larger than the pipe by least 50mm shall be provided wherever pipes pass through walls and the annular spaces shall be filled with felt lead wool and finished with retaining rings.
- 4.7** Piping work shall be carried out with minimum disturbance to the other works being done at the site. A program of work shall be chalked out in consultation with the AAI.
- 4.8** In pipe above ground level, expansion loops or joints shall be provided to take care of expansion or contraction of pipes due to temperature changes.
- 4.9** To facilitate detection of leak and isolation of defective portion of pipe, valves shall be provided in underground pipe at suitable locations. As far as possible such valves shall be provided over ground. If the valves are to be provided below ground, suitable masonry chamber with cover plate shall be provided. Locations where vehicles can pass shall be avoided for provision of valve below ground.
- 4.10** Contractor shall provide suitable cement concrete, anchor blocks of adequate dimensions as per spacing mentioned above & at all bends, tee connection and other places required and necessary for overcoming pressure thrusts in pipes wherever pipes are installed underground. Anchor blocks shall be of cement concrete 1:2:4 mix (1 cement: 2 coarse sand: 4 stone aggregate) 20 mm nominal size.

5.0 PIPE PROTECTION

- 5.1** All pipes above ground and in exposed locations shall be painted with one coat of Red Oxide Primer immediately after bringing the pipes to site and shall be painted with one coat of red oxide primer after erection & proper hydraulic testing and two or more coats of Synthetic Enamel Paint of approved shade on finishing.

All black steel pipes under floors or below ground shall be provided with protection against corrosion after proper hydraulic testing by application of 100mm wide and 4mm thick layer of anti-corrosive protection tape over the pipe, with overlap of 25mm minimum as per manufacturers specifications.

- 5.2** Where pipes are buried underground, after treated, the same shall be back filled with the excavated soil. The top of the pipes shall not be less than 1M below the ground level. Where this is not possible, the permission of Engineer- In -charge shall be obtained for burying the pipes at lesser depth. Underground pipe shall be laid at least 2M away from the face of the building preferably along the roads and footpaths.

6.0 INSPECTION AND TESTING-Hydrant System

6.1 Inspection – General

All site fabricated work / material shall be subject to inspection in cleaned condition, prior to erection. At no event, site fabricated work / material shall be installed in position without inspection and approval by AAI. The Contractor shall ensure that each stage of fabrication is carried out in compliance with the procedures specified in the IS / NBC standards as applicable and / or specified in this document.

The contractor shall conduct sample tests of all the materials supplied at reputed laboratories / agencies as directed by AAI at his own cost and test reports are to be submitted. Inspecting officials of AAI and Local Authorities shall have the right to access

the premises of the work at any time with or without giving prior notice. All the formalities or procedures for conducting the inspections by the authorities as required by them shall be arranged by the contractor free of cost.

All testing shall be carried out in the presence of AAI / statutory authorities and test registers shall be maintained by the contractor. The contractor shall provide all material, tools, equipment, instruments, services and personnel required to perform the tests and remove debris / water resulting from cleaning and after testing free of cost.

The original test certificates of all tests conducted are to be submitted to AAI. After conducting the tests, any defects found on materials, equipment, piping, etc. shall be got rectified / repaired by the Contractor without any extra cost.

6.2 Pumps

The pumps shall be tested according to the standard recommendations of the manufacturer. The following parameters are to be recorded and plotted and submitted to AAI.

Electric driven Main Fire Pump suitable for automatic operation and consisting of following, complete in all respects, as required : **(for fire hydrant and sprinkler pump)**
Horizontal type, multistage, centrifugal, split casing pump of cast iron body & bronze

impeller with stainless steel shaft, mechanical seal conforming to IS 1520. Suitable HP Squirrel cage induction motor, TEFC, synchronous speed 1500 RPM, suitable for operation on 415 volts, 3 phase 50 Hz, AC supply with IP 55 protection for enclosure, horizontal foot mounted type with Class-'F' insulation, conforming to IS-325.

M.S. fabricated Common base plate, coupling, coupling guard, foundation bolts etc. as required.

Suitable cement concrete foundation duly plastered with anti-vibration pads. Note: *The head of the pump is selected in a manner so as to give a minimum 3.5kgf/cm² pressure at the highest/farthest point.

Diesel engine driven main fire pump suitable for automatic operation and consisting of following, complete in all respects, as required :(Diesel Driven Pump)

Horizontal type, multistage, centrifugal pump of cast of iron body and bronze impeller with stainless steel shaft, mechanical seal conforming to IS1520.

Suitable HP, 1500 RPM water cooled with radiator, diesel engine conforming to relevant IS standard complete with auto starting mechanism, 12/24 volts electric starting equipment, diesel tank, exhaust pipe extended up to 10 m outside pump house duly insulated with

50 mm thick glass wool with 1.0 mm thick aluminum sheet cladding, residential silencer, instruments and protection as per standard specification, stop solenoid for auto stop in the event of fault with audio indications, painted with post office red colour etc. as required.

M.S fabricated, common base plate, coupling, coupling guard, foundation bolts etc. as required.

Suitable cement concrete foundation duly plastered and with anti- vibration pads. Note: *The head of the pump is selected in a manner so as to give a minimum 3.5kgf/cm² pressure at the highest/farthest point.

electric driven pressurization pump suitable for automatic operation and consisting of following, complete in all respects, as required : (Jockey Pump for fire hydrant and sprinkler pump)

Horizontal type, multistage, centrifugal pump of cast iron body and bronze impeller with stainless steel shaft, mechanical seal conforming to IS: 1520.

Suitable HP squirrel cage induction motor TEFC type suitable for operation on 415 volts, 3 phase 50 Hz AC supply with IP 55 class of protection for enclosure, horizontal foot mounted type with Class-'F' insulation, conforming to IS : 325.

M.S. fabricated Common base plate, coupling, coupling guard, foundation bolts etc. as required.

Suitable cement concrete foundation duly plastered and with anti- vibration pads.

Note: *The head of the pump is selected in a manner so as to give a minimum 3.5kgf/cm² pressure at the highest/farthest point.

- a) Discharge Q
- b) Pressure P or Head H
- c) Motor voltage and current.
- d) Efficiency

The power consumption is to be computed and cross checked with manufacturer's data. Any abnormalities, if noted, shall be brought to the notice of the manufacturer

and necessary corrective action be taken before commissioning and handing over, without any extra cost. Manufacturers test certificates shall also be submitted to AAI for verification.

6.3 Piping

All piping shall be tested by filling water, removing air locks, foreign materials, etc. and applying pressure at 1.5 times of the maximum working pressure and see that the no pressure drop is within 0.5 kg/cm². The testing shall be carried in sections by blocking both ends or closing the valves provided. After completion of the installation and connecting to the mains of pumping system the installation shall once again be tested and rectify breakage if any or replace the defective material, free of cost.

At least 10% of the total joints on pipes shall be tested by radiography as per relevant IS code. Holiday tests shall preferably be carried out by flexible and detachable ring probe, which shall enable the entire 360 deg. of the surface of the pipe to be scanned.

7.0 Electrical Panel –

EPC shall be designed Fire Fighting panel as per actual ratings and submit the project manager for approval before fabrication, also provide logic controls. For switchgear, rating / panel specification please refer electrical specification.

7.1 Hydrant system

The entire hydrant system shall be tested in the presence of AAI to ascertain the functioning of each system, equipment, etc. as desired by AAI. The contractor shall hand over the system only if it is proved that the system performs as per the specifications.

7.1.1 Operation of pumps

All the pumps shall be operated by both auto / manual modes and shall have automatic starting and stopping arrangements to maintain the system pressure.

Jockey pump shall not be in operation while the main pump is in operation. Under normal conditions, the water pressure in the hydrant lines shall be 7 kg / sq.cm, and the auto/manual switch shall be in the auto mode. When the pressure drop is up to 6 kg/sq.cm, the jockey pump shall start automatically through pressure switches arrangements and when pressure develops to 7 kg / sq.cm the pump shall stop automatically. The jockey and main pumps shall not be in operation simultaneously.

7.2 PAINTING

7.2.1 After the piping has been installed, tested and run for at least ten days. The piping shall be given two finish coats of approved color.

7.2.2 The direction of flow of fluid in the pipes shall be visibly marked in white arrows or as directed by the AAI.

8.0 VALVES & ACCESSORIES

Sluice valve conforming to IS: 780 or butterfly valve conforming to IS: 13095 shall be provided. All valves shall be suitable to withstand the pressure in the system and rating shall be PN 16. All valves shall be right-handed (i.e. handle or key shall be rotated clockwise to close the valve), the direction of opening and closing shall be marked and an

open/ shunt indicator fitted.

8.1 SLUICE / GATE VALVES

Valves above 65 mm (inside screw and non-raising screw type) shall be of Cast Iron body and Gunmetal seat with double flanged ends and valve wheel & valves upto 50 mm dia shall be of gun metal. They shall conform to type PN16 of IS 14686. Sluice valves upto 65mm (outside screw raising spindle type) shall be of Gunmetal Full way Valve with wheel tested to 20 Kg /cm² class-II as per I.S: 778 with female screwed ends. Valve wheels shall be of right hand type and have an arrow head engraved or cast thereon showing the direction for turning open and close.

8.2 BUTTERFLY VALVES

8.2.1. The Butterfly Valve shall be suitable for waterworks.

8.2.2 The material of valves shall be as under: -Body- Cast iron
Disc - Cast Bronze or Stainless Steel
Seat - Either integral or nitrile rubber O-ring-Nitrile / Silicon

8.2.3 The Valve shall be fitted between two flanges on either side of pipe flanges. The Valve edge rubber shall be projected outside such that they are wedged within the pipe flanges to prevent leakages.

8.3 NON-RETURN VALVES

Non-return valves shall be of Cast Iron body and gun metal seat. They shall conform to IS 5312 and have companion flanges. They shall be Dual Plate Type suitable for both horizontal and vertical installation. An arrow mark in the direction of flow shall be marked on the body of the valve.

8.4 AIR RELEASE VALVES

Air release valve shall be provided at all highest points in the piping system for air vent of the double float type with G.M. body, vulcanite balls, rubber sealing, etc. Air release valves shall be of the sizes specified and shall be associated with an equal size forged ball valve.

8.5 BALL VALVES

8.5.1 The Ball Valve shall be made from forged brass conforming to PN 16. The valve shall be internally threaded to receive pipe connections.

8.5.2 The Ball shall be made from brass and machined to perfect round shape and subsequently chrome plated. The seat of the valve body bonnet gasket and gland packing shall be of Teflon.

8.5.3 The handle shall be of chrome plated steel with PVC jacket. The handle shall also indicate the direction of 'open' and 'closed' situations. The gap between the ball and the Teflon packing shall be sealed to prevent water seepage.

8.5.4 The handle shall also be provided with a lug to keep the movement of the ball valve within 90 degrees.

8.6 STRAINER

Strainers shall be preferably of the approved type with fabricated steel bodies. Strainers shall be fabricated by minimum 1.0 mm thick stainless steel sheet with 3 mm dia. perforation holes. Strainers shall be provided with flanges or threaded sockets as required. They shall be designed so as to enable blowing out accumulated dirt and facilitate removal and replacement of screen without disconnection of the main pipe.

8.7 PRESSURE GAUGES

Pressure gauges shall be of 150mm dia. dial with Bourdon tube element of SS 316 and of appropriate range and scale division shall be in metric unit marked in black on white dial etc. complete with all accessories including shut off gauge valve etc. duly calibrated before installation. Care shall be taken to protect pressure gauges during pressure testing.

8.8 PRESSURE SWITCHES

It shall be of industrial type, single pole, double throw electric pressure switching designed for starting or stopping equipment within the pressure of the system drops or exceeds the pre-set limits. All switches shall have ¼" BSP (F) inlet connection and screwed cable entry for fixing cable gland. The pressure switch shall have a rating of 4-20 kg/cm² with 0.8 to 3 kg. Differential pressure setting. Maximum working pressure shall be 28 kg/cm² with auto reset.

8.9 FLEXIBLE CONNECTION FOR PUMPS

All suction and delivery lines shall be provided with double flanged reinforced neoprene flexible pipe connectors. Connectors should be suitable for a working pressure of each pump. Length of the connector shall be as per manufacturer's details.

9.0 EXTERNAL YARD HYDRANTS

The Contractor shall provide External Fire Hydrant in the Ring or on External FireLine as per requirements/drawings. The spacing of the hydrants and the distance from the building shall be maintained as per latest relevant codes, unless specified.

Yard hydrants shall be located at a minimum distance of 2 m. but not more than 15 m from the building face. The yard hydrants shall be accessible and should normally be provided near boundary wall / along road. While locating yard hydrants it should be ensured that same do not become hindrance in vehicular movement or entrance to the building. Yard hydrants, should be located around the building in such a way that it should be possible to fight fire on any face of the building from the nearest hydrant. A distance of 45m from hydrant to hydrant will be adequate.

Fire Hose Cabinet (FHC) shall be fabricated of 2 mm thick M.S. sheet of suitable size. The fire hose cabinet shall have glass front double door with common lock & keys and break glass recess for keys, all complete. Yard Hydrant will include the

following accessories:

(i)	Connection from ring main with 80 mm dia. MS Pipe	
(ii)	63 mm dia. single head landing valve	- 1 No.
(iii)	Butterfly / Sluice Valve 80 mm dia.	- 1 No.
(iv)	Hose pipe 63 mm dia. 15m. long with male and female coupling at both ends	- 2 Nos.
(v)	Branch pipe 63 mm dia. with 20 mm(nominal internal diameter) nozzle and suitable for instantaneous connection.	- 1 No.

The FHC shall be painted with post office red colour or as per requirement. The words "yard hydrant" or "hydrant" shall be lettered on the glass of 75mm high in white or red paint. Top surfaces shall be slopped for water discharge. Vents shall also be located on sides of the Hose Box.

A brick pedestal shall be constructed for supporting the hose box. All surfaces shall be plastered with 1:4 ratios (1 cement: 4 fine sand) mortar. The cabinet shall be installed near the External Hydrant.

10.0 INTERNAL HYDRANTS

10.1 Every Riser will be provided with the following at every floor including terrace:

SS single headed Hydrant valve	- 1 No.
Fire Hoses 63mm, 15 M long with accessories	- 2 Nos.
SS Short branch	- 1 No.
First Aid hose Reel (30 meter)	- 1 No.
Fireman's Axe	- 1 No.
Pressure Gauge	- 1 No.

11.0 FIRST-AID HOSE REEL EQUIPMENT

11.1 First aid hose reel equipment shall comprise reel, drum which can swing upto 180 degrees with hose, guide fixing wall bracket, hose tubing, globe valve, stopcock and nozzle. The water inlet is connected to the riser pipe by means of 37 mm socket and valve. The hose tube can be pulled out easily for the purpose of discharge of water on fire. The length of hose tube shall be such that the nozzle of the hose can be taken into every room and within a range of 6 M from any part of the room. This shall conform to IS: 884 - 1969. The hose tubing shall conform to IS: 12585 (Thermoplastic textile reinforced) type - 2. The drum shall be fabricated from GI sheet of minimum 18-gauge thickness.

11.1.1 The hose tubing shall be 20 mm (nominal internal) dia. and 30 m long (Min). The SS nozzle 5mm and shutoff valve shall be of 25 mm size to shut off the water supply to the Hose Reel.

11.1.2 The fixing bracket shall be of swinging type. Operating instructions shall be engraved on the assembly. This heavy duty mild steel and cast iron brackets shall be conforming to IS: 884 - 1969. The first-aid hose reel shall be connected directly to the

M.S. pipe riser through a 25mm dia. pipe.

- 11.1.3 A MS bracket shall be fixed on the wall to which the first aid hose reel shall be bolted. The bracket shall be of 40x40x5mm thick MS angle to form a square of 400x400 mm (approx.). The units shall be fabricated in factory and all joints shall be finished with grinder and shall be spray painted after single coat of primer.
- 11.1.4 The water flow rate shall be not less than 24 lpm and the range of jet shall be not less than 6 m.

12.0 VALVE CHAMBERS

Contractor shall provide suitable Brick Masonry Chamber in cement mortar 1:4 (1 cement: 4 coarse sand) with 150mm thick cement concrete foundations in 1:5:10 mix (1 cement: 5 fine sand: 10 graded stone aggregate) 40 mm nominal size. The brick masonry work shall be plastered with 12 mm thick finished with a floating coat of neat cement inside. The TOP of chamber shall be covered with cast iron surface box as approved by Engineer- In -Charge.

13.0 PORTABLE FIRE EXTINGUISHER

Portable fire extinguishers shall be provided as per IS: 2190.

14.0 Clean Agent Type Extinguisher– 4 kg capacity

- The Fire Extinguisher 4 Kg. Capacity filled with (FK 5-1-12) from approved manufacturer.
- It shall be operated upright, with a squeeze grip valve to control discharge. The plunger neck shall have a safety city, fitted with a pin, to prevent accidental discharge. It shall be pressurized with Dry Nitrogen, as expelling. The Nitrogen to be charged at a pressure of 25 kg / cm².
- Body shall be of mild steel conforming to relevant IS Standards. The neck ring shall be also mild steel and welded to the body. The discharge valve body shall be forged brass or leaded bronze, while the spindle, spring and siphon tube shall be of brass. The nozzle shall be of brass, while the hose shall be of braided nylon. The body shall be cylindrical in shape, with the dish and dome welded to it. Sufficient space for Nitrogen gas shall be provided inside the body, above the powder filling.
- The extinguisher shall be treated for anti-corrosion internally and externally, and externally painted with Fire Red paint valve. The paint shall be stove enameled / powder coated. The cartridge shall be as per relevant IS. The extinguisher, body and cap shall be able to with stand an internal hydraulic pressure of 25 kg/cm². It shall have external marking with letter A, of 2.5 cm height, in block letters within a triangle of 5 cm each side. The extinguisher shall be upright in operation, with the body placed on ground, and discharge tube with nozzle held in one hand to give a throw of not less than 6 meter, and continue so for at least 60 sec. The extinguisher body shall be clearly marked with ISI stamp (IS 940).

14.1 CARBON DIOXIDE EXTINGUISHER– 4.5 kg capacity

- The Carbon Dioxide Extinguisher shall be as per IS: 15683.
- The Body shall be constructed of seamless tube conforming to IS: 7285, and having a convex dome and flat base. Its dia. shall be maximum 140 mm, and the overlay height shall not exceed 720 mm.
- The discharge mechanism shall be through a control valve conforming to IS: 3224. The internal siphon tube shall be of copper or aluminum conforming to relevant specifications.
- Hose pipe shall be high pressure braided Rubber hose with a minimum burst pressure of 140 kg/cm², and shall be approximately 1.0 meters in length having internal dia. of 10 mm. The discharge horn shall be of high quality unbreakable plastic with gradually expanding shape, to convert liquid carbon dioxide into gas form. The handgrip of Discharge horn shall be insulated with Rubber of appropriate thickness.
- The gas shall be conforming to IS: 307 and shall be stored at about 85 kg/cm². The expansion ratio between stored liquid carbon dioxide to expanded gas shall be 1:9 times and total discharge time shall be minimum 10 sec. and Maximum 25 sec.
- The Extinguisher including components shall be ISI Mark.

15.0 SPRINKLER SYSTEM SYSTEM DESIGN

Automatic sprinkler system shall be provided for all areas as per requirement with permitted exceptions e.g. electrical switch rooms, power transformers and D.G. rooms, Panel rooms, Electrical rooms, Battery room, Server room, staircase & lift well, or any other area / room where the water discharged from sprinkler may cause a hazard as identified.

- (a) Sprinkler heads shall be provided at approximate spacing to cover 9 m² for ceiling sprinkler per Sprinkler head or as per specific requirements to meet the approval of the authority having jurisdiction. The spacing shall also be in conformity with the drawings and properly coordinated with Electrical Fixtures, Ventilation Ducts and Grills and other services along the ceiling.
- (b) Types of sprinklers to be used shall be (quick response type with K-115, 160 minimum) upright fire/pendent type/ concealed sprinkler/side wall standard throw/extended throw sprinkler all as per approval of AAI/ Engineer- in-charge
- (c) Installation of sprinkler piping
All fire-fighting piping shall be installed with electro-galvanized sprinkler clamps and should have been independently tested by Lloyds Register for minimum of 3 times of safe working load. Dimensions and minimum load bearing capacity of sprinkler clamps should be as per below.

Dimensions and minimum load bearing capacity of sprinkler clamps should be as per below table

Size	Width in mm	Thickness in mm	Hole dia in mm	Safe working load in Kg
3/4"	16	1.2	11	143
1"	16	1.2	11	143
1.25"	16	1.2	11	143
1.5"	16	1.2	11	143
2"	16	1.2	11	143
2 1/2"	19	1.6	11	304
3"	19	1.6	11	304
3 1/2"	19	1.6	11	304
4"	19	1.6	11	304
5"	25	2	13	571
6"	25	2	13	571
8"	25	2.5	13	714

15.1 SPRINKLER HEADS

Sprinkler heads shall be Chrome finished Brass / Gunmetal with quartz bulb with a temperature rating of 68°C (change with height). Sprinkler heads shall be of type and quality approved by the local fire brigade authority. The inlet shall be screwed. Sprinkler heads shall be pendent, recessed or special application side wall Sprinkler types as shown in drawings. All Sprinklers should have the Specifications as far as possible as per NFPA requirements and shall be UL/FM approved.

Table 36 Fusible Link Type
(Clause 15.4)

Temperature Rating °C (1)	Colour of Yoke Arms (2)
68/74	Natural
93/100	White
141	Blue
182	Yellow
227	Red

The nominal bore shall be 15 mm dia and colour of bulb liquid shall be red. The below false ceiling shall also be provided with a double plate captive rosette assembly to seal the junction between the pipe and the false ceiling.

15.2 Sprinkler flexible Hose

Rigid pipe offsets or return bends for sprinkler drops, the Multiple-Use Flexible Stainless Steel Sprinkler Drop System used to locate sprinklers as required by final finished ceiling tiles and walls.

The drop system must be with ANNULAR CORRUGATION, which allows the flex drop to be bended just after the end fittings. The drop system shall consist of a BRAIDED type 304 stainless steel flexible tube, zinc plated steel Male threaded nipple for connection to branch-line piping, and a zinc plated steel reducer with a female thread for connection to the sprinkler head and with a numbering on the reducer to ease the process for vertical positioning of the sprinklers.

The drop shall be FM & VDS approved & minimum number of 90 Degrees bends allowed should be 3 & Minimum Bend Radius should be 178 mm as per FM & 76.2 mm as per VDS.

Union joints shall be provided for ease of installation.

Flexible drop should have max. Working pressure of: 200 PSI / 13.75 bar – FM Approval | 232 PSI / 16 bar – VDS Approval

The flexible drop shall be attached to the ceiling grid using a one-piece open gate Series Ab7 Bracket.

16.0 ALARM VALVE & AUTOMATIC WATER MOTOR GONG VALVE

The alarm valve & water motor gong valve is to be provided on all the Sprinkler main delivery pipes (or Installation Control Valves) as per approval of authority having jurisdiction. No. of installation valves and risers shall be provided as per IS:15105.

16.1 The Installation Control valve (ICV) shall be double seated clapper type check valve. The Body and cover shall be made from Cast Iron to IS: 210 Grade FG 200. The seat and seat clamp shall be made from bronze to IS: 318, LTB II grade. The sealing to the seat shall be neoprene gasket. The hinges pin and ball shall be from stainless steel.

16.2 It shall be vertically mounted and the direction of water travel shall be indicated on the surface. It shall be rated to 12 kg / cm² and tested to 25 kg / cm² pressure.

16.3 A By-pass check valve shall be fitted to adjust minor and slow variations in water pressure for balancing so as to avoid any false alarm.

16.4 The valve shall also be provided with a Test Control Box. The Box shall house a lever to test and operate the ICV. A brass strainer shall also be provided at the point of water supply to the Alarm gong. A Retarding Chamber shall also be provided. The Chamber shall be able to balance the water pressure in case of water line surges.

16.5 Each Installation Control Valve shall have two sets of pressure Gauges with brass ball valve type shut off.

16.6 A Water Motor Alarm shall be mechanically operated by discharge of water through an impeller. The drive bearing shall be weather resistant. A strainer shall be provided on line before the nozzle. The Gong piece shall be constructed from bronze to IS 318, 2 TB II Grade & base of cast iron. The motor Housing, Rotor and Housing Cover shall be pressure die cast aluminum.

16.7 A brass automatic ball drop valve with the retard chamber shall be provided.

17.0 INSPECTOR TEST VALVES

The Inspectors Test Valve assembly is to be provided on the Sprinkler System pipes in location as per approval of authority having jurisdiction.

18.0 FLOW SWITCHES

The Flow Switches are to be provided on the Sprinkler System pipes for each zone complete with all necessary wiring up to monitor modules as per instructions of the Engineer –In-Charge.

19.0 FIRE FIGHTING PUMPS

The general requirement of water pumps for main fire pump, jockey (pressurization) pump and sprinkler pump are detailed below. The discharge and head of the pumps shall be designed as per NBC-2016/IS: 15105.

20.0 FIRE, SPRINKLER, JOCKEY PUMPS & TERRACE PUMP

- 20.1** The main fire pump /sprinkler pump/diesel pump shall be split casing/multi/ single stage horizontal centrifugal single outlet with cast iron body and bronze dynamically balanced impellers.
- 20.2** The Jockey pump & terrace pump shall be end suction single stage horizontal centrifugal single outlet with cast iron body and bronze dynamically balanced impellers while.
- 20.3** Connecting shaft shall be stainless steel & shall be accurately machined. Shaft shall be balanced to avoid vibrations at any speed within the operating range of the pump & with bronze sleeve and grease lubricated bearings. The centrifugal pump shall conform to IS: 1520.
- 20.4** Pumps shall be connected to the drive by means of spacer type love-joy coupling /flexible coupling, which shall be individually balanced dynamically and statically.
- 20.5** The coupling couples the prime mover with the pump shall be provided with a sheet metal guard.
- 20.6** The shaft seal shall be mechanical type, so as to allow minimum leakage. A drip well shall be provided beneath the seal.
- 20.7** The bearings shall be heavy duty ball / roller type suitable for the duty involved. These shall be grease lubricated and shall be provided with grease nipples/cups. The bearing shall be effectively sealed against leakage of lubricant or entry of dust or water.
- 20.8** Main fire pumps / Diesel Engine driven Fire Pumps / terrace pump / jockey pump shall be capable of delivering not less than 150% of the rated capacity of water at a head of not less than 65% of the rated head. The shut-off head shall not exceed 120% of the rated head.

21.0 MOTORS FOR ELECTRIC DRIVEN PUMPS

- 21.1** Electrically driven pumps shall be provided with totally enclosed fan cooled induction motors.
- 21.2** Motors for Main fire pumps shall be at least equivalent to the horsepower required to drive the pump at 150% of its rated discharge and shall be designed for continuous full load duty and shall be design proven in similar service.
- 21.3** Motors shall be suitable for 415 volts \pm 10%, 3 Phase, 50 Hz, A.C supply with class –F insulation, TEFC and conform to IS: 325.

Motors shall be capable of handling the required starting torque of the pumps.

22.0 ACCESSORIES AND FITTINGS

22.1 The following accessories shall be provided with each pump among other standard accessories required:

- a) Coupling guard for horizontal split casing pumps.
- b) Lubrication fittings and seal piping.
- c) Test and / or air vent cocks

22.2 Following fittings shall be provided with each pump among other standard fittings required:

- a) Butterfly / Sluice valves on suction & discharge. Reducers to match the sizes of the connected pipe work. NRV at discharge.
- b) Suction and discharge pressure gauges not less than 100 mm dia. dial size and of the appropriate rating with gauge valves etc. Suction gauge shall be of compound type.

22.3 25mm GI gland drains.

23.0 INSTALLATION

Pump and motor /engine assembly shall be mounted & arranged for ease of maintenance and to prevent transmission of vibration and noise to the building structure or to the pipe work or as per manufacturer's recommendations. Pump sets shall be mounted on machinery isolation cork or any other equivalent vibration isolation fittings. Concrete floating foundation shall be provided as per approved shop drawings and specifications. The height of foundation shall be so decided that the total weight of foundation on block is 1.5 times the operating weight of the pump assembly. The isolation pads, foundation bolts etc. shall be supplied by the Contractor. Contractor shall ensure that the foundation bolts are correctly embedded. Angle iron frame of size 35mm X35mm X 3mm shall be provided on the top edges of the foundation. The length & width of the foundation shall be such that 100mm space is left all around the base frame.

Pump sets shall preferably be factory aligned, wherever necessary, site alignment shall be done by competent persons. Before the foundation bolts are grouted and the couplings are bolted, the bed plate levels and alignment results shall be submitted to the AAI. The suction / discharge pipe shall be independently supported and their weight shall not be transferred to the pump. It should be possible to disconnect any pump for repair without disturbing the connecting pipe line.

24.0 INSPECTION AND TESTING - SPRINKLER SYSTEMS

It shall be factory tested for operation characteristics and chemical tests. Necessary test results shall be submitted before supply. The contractor shall establish the discharge of the sprinkler during the testing at site.

Sprinkler alarm valve

The pump shall start automatically and maintain pressure at the appropriate flow rate. The drain valve fitted above the alarm valve shall be opened and the time taken for the alarm gong to operate be noted. There shall not be a significant variation in the

timing. The pressure at the "C" gauge of the alarm valve shall be noted at the full load condition of the pump and the value should match with that of the specification. The proper functions of the alarm gong associated with the alarm valve and its level of audibility shall be checked. An audibility level of 85 db above the background noise level is required. Necessary testing equipment shall be arranged by the contractor free of cost.

While conducting the tests, the water flowing through the test valve shall be equivalent to the flow through one sprinkler. It should auto start the pumps and activate the alarm motor and gong. When the test valve is closed, the water flowing through the test valve should stop.

25.0 PAINTING

After complete installation and testing, pumps accessories and fittings shall be given two coats of approved finishing paint.

25.1 AIR VESSEL FOR FIRE PUMPS

Provide an air vessel fabricated from M.S. sheet with dished ends and suitable supporting legs, air vessel shall be provided with a 100mm dia. flanged connection from pump, one 50mm dia. drain with valve, one gunmetal water level gauge and 25mm sockets for pressure switches. The vessel shall be 450mm dia. x2000mm high and tested to 1.5 times of the working pressure or 12 Kg/Cm², whichever is greater.

The fire pumps shall operate on drop pressure in the mains which are kept in uniform pressure at 7kg/cm² during nonoperational period automatically or manually as per operative head of fire pumps designed by the contractor.

CAPACITY ARE MINIMUM/INDICATIVE.EPC CONTRACTOR NEEDS TO DESIGN AS PER NBC 2016,IS 15105 AND LATEST CODES.

Fire Pump	Service	Nos.	Operating Pressure <u>Cut In</u> (In Kg / cm ²)	Operating Pressure <u>Cut Out</u> (in Kg / cm ²)	Remarks
Jockey pump (Hydrant / Sprinkler)		2	8.3	8.8	To auto start and auto stop on pressure switch on air vessel.
Main pump (Hydrant)		One	7.8	Push button manual	To auto start on pressure switch on air vessel and manual off.
Main pump (Sprinkler)		One	7.3	Push button manual	To auto start on Pressure switch on air vessel and manual off.

Diesel Fire Pump	two	6.8	Push button manual	To auto start o pressure switch on ai vessel and manual off.
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Once started during emergencies the pumps will maintain its operative head for which pumps are designed.

(The above ratings will be adjusted finally at the time of commissioning as per site requirement and final setting shall be kept as per approval of AAI).

25.2 DIESEL FIRE PUMP Scope

The details of requirements of the standby fire pump, operated by a diesel engine are detailed below:

General

The diesel pump set shall be suitable for automatic and manual operation, complete with the necessary automatic starting gear for starting on wet battery system and shall be complete with all accessories. Both engine and pump shall be assembled on a common base plate, fabricated from mild steel channel.

Drive

The pump shall be only direct driven by means of a hollow set / flexible coupling. Coupling guard shall also be provided. The speed shall be 1500 RPM.

Fire Pump

- i. The fire pump shall be horizontal split casing multi-stage centrifugal type. It shall have a capacity to deliver the discharge as specified, developing adequate head so as to ensure a minimum pressure of 3.5 Kg / cm² at the highest and the farthest outlet. The pump shall be capable of giving a discharge of not less than 150% of the rated discharge at a head of not less than 65% of the rated head. The shut off head shall be within 120% of the rated head.
- ii. The pump casing shall be of cast iron to grade FG 260 / 200 to IS: 210 and parts like impeller shaft sleeve, wearing-ring etc. shall be of non-corrosive metal like bronze. The shaft shall be of stainless steel. The pump shall be provided with mechanical seal.
- iii. The pump casing shall be designed to withstand 1.5 times the working pressure.
- iv. Bearings of pump shall be effectively sealed to prevent loss of lubricant or entry of dust or water.

25.3 DIESEL ENGINE

23.3.1 **Environmental Conditions** - The engine shall be required to operate under the conditions of ambient temperature and humidity suitable at site.

23.3.2 **Engine Rating** - The engine shall be multi cylinder / vertical four stroke cycle, water cooled, developing suitable HP at the operating speed specified to drive the fire pump.

cold starting type without the necessity of preliminary heating of the engine cylinders or combustion chamber (for example, by wicks, cartridge, heater plugs etc.). Continuous capacity available for the load shall be exclusive of the power requirement of auxiliaries of the diesel engine, and after correction for altitude, ambient temperature and humidity for the specified environmental conditions as mentioned. This shall be at least 20% greater than the maximum HP required to drive the pump at its duty point. It shall also be capable of driving the pump at 150% of the rated discharge at 65% of rated head. The engine shall be capable of continuous non-stop operation for 8 hours and at least 3000 hours of operation before major overhaul. The engine shall have 10% overload capacity for one hour in any period of 12 hours continuous run. The engine shall accept full load within 15 seconds from the receipt of signal to start. The diesel engine shall conform to BS 649 / IS 1601 / IS 10002, all amended upto date.

23.3.3 Engine Accessories - The engine shall be complete with the following accessories:

-
- Flywheel dynamically balanced.
- Direct a coupling for pump and coupling guard.
- Radiator with hoses, fan, water pump, drive arrangement and guard.
- Corrosion Resister.
- Air cleaner dry type.
- Fuel service tank support, semi-rotary pump and fuel oil filter with necessary pipe work.
- Pump for lubricating oil and lub. Oil filter.
- Elect. Starting battery (12 V / 24V).
- Exhaust silencer with necessary pipe work.
- Governor.
- Instrument panel housing all the gauges, including Tachometer, hourmeter and starting switch with key (for manual starting).
- Necessary safety controls.
- Winterization arrangement.
- Hand operated semi rotary pump for filling the service tank.

23.3.4 Fuel System: The fuel shall be gravity fed from the engine fuel storage tank to the engine driven fuel pump. The engine fuel storage tank shall be floor mounted with proper support etc. Dyke wall shall be provided all around fuel storage tank as per IS requirement to avoid spillage of oil.

All fuel tubing in the engine shall be with copper and fuel piping from day oil tank to engine shall be MS and or with Reinforced flexible hose connection at engine side. Plastic tubing shall not be permitted.

The fuel tank shall be welded Steel Construction (3mm Thick) and of 200 liter capacity sufficient to allow the engine to run on full load for at least 8 hours. The tank shall be complete with necessary supports, level indicator (Protected against mechanical injury) inlet, outlet, overflow connection and drain plug and piping to the engine fuel tank. The outlet shall be so located as to avoid entry of any sediment into the fuel line to the engine.

Tank shall be provided with epoxy coat from inside and outside with one coat of Red oxide primer and two or more Coats of Synthetic enamel paint of approved shade.

A semi rotary hand pump for filling the daily service tank together with hose pipe of 5 m

long with a foot valve etc shall also form part of scope of supply within the quoted cost.

- 23.3.5 **Starting system** - The starting system shall comprise necessary batteries 12V / 24V volts starter motor of adequate capacity and axle type gear to match with the toothed ring on the flywheel. Bi metallic relay protection to protect starting motor from excessively long cranking runs suitably integrated with engine protection system shall be included within the scope of the work.

The battery capacity shall be suitable for meeting the needs of the starting system. The battery capacity shall be adequate for 10 consecutive starts without recharging with cold engine under full compression.

Three attempt starting facility shall be provided if engine fails to start after third attempt, the engine shall be locked out and suitable audio visual alarm shall be given to indicate engine failure.

The scope shall cover all cabling, terminals, initial charging etc.

- 23.3.6 **Exhaust system** - The exhaust system shall be complete with silencer suitable for outdoor installation, and silencer piping including bends and accessories needed to be taken out of the building as per statutory requirement. The Contractors are advised to see the drawing and site to assess the length and size of exhaust pipe required. The total backpressure shall not exceed the engine manufacturer's recommendation. The exhaust piping shall be suitably lagged with 50 mm thick glass wool & 1 mm thick Al. sheet cladding within the quoted cost.

- 23.3.7 **Engine shut down mechanism** - This shall be manually operated and shall return automatically to the starting position after use.

- 23.3.8 **Governing System** - The engine shall be provided with an adjustable governor to control the engine speed within 5% of its rated speed under all conditions of load up to full load. The governor shall be set to maintain rated pump speed at maximum

pump load.

An over speed shutdown device to shut down the engine at a speed approximately 20% above rated engine speed with manual reset, so that the automatic engine controller will indicate an over speed signal until the device is manually reset to normal operating position.

23.3.9 **Cooling System**: The engine shall be radiator water cooled. The radiator assembly shall be mounted on the engine. The radiator fan shall be driven by the engine as its auxiliary with multiple fan belts. When half the belts are broken, the remaining belts shall be capable of driving the fan. Cooling water shall be circulated by means of an auxiliary pump of suitable capacity driven by the engine in a closed circuit.

23.3.10 **Engine Instrumentation** - Engine instrumentation shall include the following:

- Lub. Oil pressure gauge.
- Lub. oil temperature gauge
- Water pressure gauge
- Water temperature gauge
- Tachometer
- Hour meter

The instrumentation panel shall be suitably mounted on the engine.

(i) **Engine Protection Devices** – The following engine protection and automatic shutdown facilities shall be provided: -

- Low lub. oil pressure
- High cooling water temp
- High lub. oil temperature
- Over speed shut down

(j) **Pipe work** - All pipe lines with fittings and accessories required shall be provided for fuel oil, lub. Oil and exhaust systems.

The fuel tubing to the engine shall be MS C–class pipe with flexible hose connections where ever required.

(k) **Anti Vibration Mounting** - Suitable anti-vibration mounting duly approved by AAI shall be employed for mounting the unit so as to minimize transmission of vibration to the structure.

(l) **Battery Charger** - Necessary float and boost charger shall be incorporated in the control section of the power and control panel, to keep the battery under trim condition. Voltmeter to indicate the state of charge of the batteries shall be provided.

24 **MOTOR CONTROL SYSTEM**

EPC shall be designed Fire Fighting panel as per actual ratings and submit the project manager for approval before fabrication, also provide logic controls. For switchgear, rating / panel specification please refer electrical specification.

The switchboard shall be floor mounted, free standing, cubical type, compartmentalized and shall be factory built fabricated by one of the approved switch board manufacturer. The board shall be fabricated from 2mm thick CRCA sheet and powder coated after seven tank process. The board shall be fabricated with IP 54 degree of protection suitable for operation of 415 volt $\pm 10\%$, 3 phase, 4 wire, 50Hz, AC supply. The switch board shall have provision for termination of cables from top as well as bottom with suitable knockouts. The layout shall be designed for convenient connections and inter- connections with various switchgears. Connections from individual compartments to cable alleys shall be such as not to shut down healthy circuits in the event of maintenance work becoming necessary on a defective circuit. A base channel of 75mm

5mm thick shall be provided at the bottom. A maximum of 200mm space between the floor and bottom most panel of unit shall be provided. The bus bar shall be of aluminium complete with heat shrinkable PVC sleeves. The fabrication of switch board shall be taken up only after the drawings for the fabrication of the same are approved by the Engineer –in – charge.

Control panel shall contain starters and safety protection for hydrant, sprinkler, jockey pump motors and diesel controls etc. It shall also house the switchgears for incoming as well for outgoing supply. Provision of voltmeter (for incomer) & ammeter for incomer as well as for measuring the current drawn by each motor with selector switch, a set of LED indicating light for incoming phases as well as status indication of each equipment. The voltmeter & LED indication lamps shall be protected by MCBs.

All the motors shall be provided with fully automatic Star Delta starters with motor duty MCCBs for short circuit protection only (ICS = 100% ICU) & Overload Relays with contactors of suitable range & ratings for overload protection. Single phase preventers shall be provided for all 3 phase motors. Single phase preventer shall be in conformity with relevant ISI standards. Single phase preventers shall act when failure of one or more phases. Single phase preventer shall be voltage operated and of approved make.

The MCCB for incomer shall be with Thermal magnetic release & should provide adjustable setting for overload and short circuit protection with ICS = 100% ICU.

Interlocking shall be provided between switch and the door in such a way that the door of the panel cannot be opened when the supply is ON.

The panel shall be provided all identification tags, danger board etc as per standard.

All control panels shall be provided with detailed control circuit diagram indicating the terminal numbers and color coding of the wires used in the panels. This diagram shall be pasted on the inner side of the cover and protected with PVC transparent lamination.

For detailed specification of switchgears & accessories, detailed specifications under electrical sub head of contract shall be followed.

Motor control panel shall be designed compatible to BMS system.

26.0 CONTROL SYSTEM

The system shall be designed for operation automatically so that as and when water is drawn from the system through any hydrant, the pumps will operate automatically and feed water in to the system. However once a fire pump starts working, it will be stopped manually (except jockey pump) or on account of any fault or non-availability of power supply to electrical pumps or low water level in UG tank control system shall be compatibility with BMS system.

Facility shall also be provided for manual operation. A selector switch for auto / manual selection shall be provided in each pump.

The Control system shall be designed to provide the following sequence of operation.

- a) The Jockey pump for Hydrant system / Sprinkler System shall maintain pressure in the hydrant system / Sprinkler System and shall operate only on account of slow pressure loss. In case of sudden pressure loss the Jockey pump shall not operate. The pump shall start when the water pressure in the system falls to a Cutout value about 1 Kg / cm² below normal system pressure and shut down when the system pressure reaches the set value. Both limits shall be adjustable.
- b) Main Electric Hydrant fire pump shall operate on account of sudden pressure loss. So long as Main electric fire pump is working the diesel Fire pump will not operate. The pump shall start when the water pressure falls to the pre-set in the system.
- c) Main Electric Sprinkler pump shall operate on account of sudden pressure loss in the sprinkler line. So long as Main electric fire pump is working the diesel Fire pump will not operate. The pump shall start when the water pressure falls to the pre-set in the system.
- d) The Diesel Fire pump (Standby Pump) will start on sudden pressure loss, only in case supply to Main Electrical Sprinkler or Hydrant Fire pump is not available or within a pre-set time the Main Electric fire pump fails to start or fails during operation. Audio-visual Alarm shall be available to indicate failure of Main electric pump.
- e) A three attempts starting facility will be provided for diesel pump.
- f) If within a pre-set time, the standby pump also fails to start or fails to develop pressure, an audio visual alarm indication shall be given at the control panel.
- g) Only one pump will be working at a time. In manual mode more than one pump can be started.
- h) Water level in UG shall be monitored and in case of low water level, pumps connected with the tank shall not operate (even on manual mode) or stop operation as the case may be. An audio-visual alarm shall be given at control panel.

27.0 SYSTEM CONTROLLER

For Controlling operation of pumps as mentioned in above clauses and indicating fault, system controller shall be provided. The system controller shall consist of Relay timers, contractors etc. and shall be designed to operate the Fire pumps with interlocking and fault indication describe in above clauses. Annunciation window shall be provided to indicate the following faults:

Low water level in UG tank.

Hydrant / Sprinkler Pump failed to Start.

Hydrant / Sprinkler Pump failed during operation. Diesel pump failed to Start. Diesel

pump failed during Operation. Supply to Hydrant / Sprinkler Pump failed. Supply to

Jockey Pump failed.

28.0 POWER CABLING

Contractor shall provide all power /control cables from the motor control centre to various motors, level controllers and other control devices. All power cables shall be aluminum conductor XLPE insulated armored and PVC sheathed and control cables of copper conductor PVC insulated armored and PVC sheathed. All Power / Control cables shall have FRLS outer Sheath and stranded conductors of 1100 Volt grade. The cables shall be in drums as far as possible and bear manufacturer's name.

Specification of cable laying shall be followed as described in Internal EI package of this tender.

29.0 CABLE TRAYS

Specification of cable trays shall be followed as described in Internal EI package of this tender.

30.0 EARTHING

Main Electrical power upto the Electrical panel(s) in Fire fighting Pump Room along with earthing shall also be considered in the scope.

All three phase motors / equipment shall be earthed with two independent earth conductors as per the requirement of Indian Electricity Rules and Regulation - 1956.

Earthing specifications shall be followed as described in Internal EI package of this tender.

31.0 COMMISSIONING

After the completion of testing and obtaining statutory approval, the system shall be commissioned. During commissioning the contractor shall establish the head, discharge, efficiency, drive connected load etc of the pumps. The discharge from the hydrant valves, sprinklers etc shall also be demonstrated. The commissioning will be for a continuous period of 7 days. The system shall be put in automatic mode and checked. The automatic operation shall be verified by releasing system pressure by opening of valves. Sprinkler system shall be tested by opening the drain valve. Automatic operation of jockey pump and main pumps (electric and diesel engine driven pumps) shall be verified. The system operation shall not be affected during the continuous operation period of 7 days. If defects noted in the system during the seven days period the same shall be rectified by the contractor in a time bound manner without any additional cost to AAI. Leakage in the piping network, if any, noted during the commissioning shall also be attended by the contractor and rectified without any additional cost to AAI. The system shall be operated in manual mode also to confirm manual operation of the system. The commissioning of the system shall be carried out in close coordination with AAI. All equipments, tools, tackles, materials, personnel etc required for the system commissioning shall be arranged by the Contractor at no extra cost to AAI.

FIRE SUPPRESSION SYSTEM

5.1 FIRE TUBE SUPPRESSION SYSTEM

Automatic fire tube suppression system shall be provided in the APFC cum AHF hybrid panel and LT panels, MDB panels, DG sync, HVAC Panel, lift panels and all other panels in terminal building having incomer above 250 Amp.

1. **General**

This includes Supply, Installation, Testing and Commissioning of gas suppression system comprising of gases/ agent approved as NOVEC1230/ FK5-1-12 gas as the extinguisher agent in Electrical Panels. Gas suppression system shall be of internationally accepted environment friendly extinguishing agent. Storage container offered shall be non-ferrous seamless type with PESO/ FM/ UL Components (Gas, tube, pressure switch, and end of line)/ LPCB approved as per Specification.

2. **Scope of Work**

- i. Supply, Installation, Testing and Commissioning of clean Agent Fire Suppression system designed to provide a uniform concentration within the electrical panels in accordance with NFPA 2001/ UL 2166/ FM).
- ii. Provide all engineering design and materials for a complete agent suppression system including storage cylinders with steel bracket, extinguishing agent, detection tube, cylinder valve and associated accessories including but not limit to; adaptors, pressure switch, tube fittings etc., required for complete operation of system.
- iii. All necessary safety requirements such as warning signs, discharge alarm shall be part of system.
- iv. The necessary nomenclature such as pressurization level, agent volume, and gross/ net weight of cylinder shall be clearly marked on cylinder.
- v. Prior to supply of material at site. Contractor must submit following documents for approval of Engineer-in-charge.
- vi. Drawing in A-4 size, clearly showing the panel, routing of tube inside the panel, location and fixing arrangement of cylinder & system components.
- vii. All doors and holes in the enclosed/ equipments should be closed or sealed to maintain the tightness of enclosure.

3. **System Description**

- i) The detection tube shall be fixed with PESO approved cylinder valve at top of cylinder. The tube shall be pressurized with dry nitrogen. In case of reach of pre- determined temperature (100-120 deg. C), the tube shall rupture, and gas shall be released from tube over the protected area.
- ii) The pressure switch shall be provided for necessary indication of discharge of gas.
- iii) The Extinguishing Agent shall be stored in cylinder as liquefied compressed gas, super pressurized with dry nitrogen at 195 psi.
- iv) The cylinder shall be equipped with brass valve, pressure gauge (to monitor agent pressure) and isolation valve for maintenance purposes. The cylinder bracket shall be of steel construction with quick release clamp.
- v) The detection tube shall be installed throughout the compartments of panel. The location and spacing of tube shall be above the hazard, to be protected.
- vi) In case of fire, the tube shall rupture at a point. The rupture of tube shall result in formation of discharge point and release the agent in uniform pattern.

- vii) With system activation, a signal should be generated via Audio Visual Alarm installed at electrical panel. There should be provision for at least one NO/ NC contact for centralized monitoring if required.

All system assemblies and components shall be subjected to the applicable testing by 3rd party testing agencies as PESO / FM/ UL.

4. System Components

The Successful tenderer shall provide an under taking from Principle Manufacturer of PESO/ CE/ UL marked product they intent to install, that manufacturer will fully support the contractor for this specific project.

- i) UL/ PESO approved Cylinder of steel construction with standard red epoxy paint finish. Cylinders shall be accompanied by original manufacturers test certificate confirming the contents of the cylinder and filled in UL/ PESO Approved plant.
- ii) All the components of gas suppression system being supplied shall be from single manufacturer only. Cylinders shall be super pressurized with dry nitrogen to an operating pressure and temperature as per manufacturer recommendations.
- iii) Each cylinder shall have pressure gauge and low pressure switch to provide visual and electrical supervision of the cylinder pressure. The low pressure switch shall be wired to the Audio Visual Alarm to provide audible and visual trouble alarm in the event of drop of pressure. The pressure gauge shall be color coded to provide an easy, visual indication of cylinder pressure.
- iv) Furnish a welded steel bracket with each cylinder assembly for holding the cylinders in a saddle with a front bracket piece that secures the cylinders.
- v) Cylinder shall be provided with a certificate provided by the company who charge with the gas mixture. The certificate shall be secured around the cylinder with chain fastener.
- vi) The Detection Tube (dielectric strength should not be less than 40 KV), LPCB/ UL approved to be Red Colour and pressurized as per system design requirement. The Detection Tube to rupture between (100-120 degree C)
- vii) The Pressure Switch should be UL/LPCB Marked having NO/ NC contact.

5. Extinguishing Agent (NOVEC -1230 / FK-5-1-12)

- i) Extinguishing agent shall be UL listed / FM approved.
- ii) The ozone depletion potential should be zero. iii) The extinguishing agent should be filled in an UL Listed / PESO approved filling station.

6. Installation

- i) The system shall be installed on basis of approved drawing.
- ii) The installation/final connections shall carry out in direct supervision of representative of Manufacturer/ authorized distributors.
- iii) The executing agency should be an authorized system installer of OEM having enough experience of installation of Trace Tube Systems.
- iv) Cylinder shall be located so that they are not subjected to mechanical, chemical or other damage.
- v) All system components shall be capable of withstanding heat of fire and severe weather conditions.
- vi) Detection Tube to be properly secured inside the panel by Clips / Tie etc.
- vii) The Detection Tube outside the panel should be protected in flexible conduit.

- viii) Inspection certificate should be pasted on cylinder clearly marking next due date of inspection.

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5.2 GAS SUPPRESSION SYSTEM FOR TOTAL ROOM FLOODING

SYSTEM

1.0 Gas Suppression System

The bidder shall supply, Design, install, test and put in operation NOVEC1230/ FK-5-1-12 based fire suppression system. The fire suppression system shall include and not be limited to gas release control panel, UL/ PESCO/ LPCB/ Vds listed cylinders, discharge valve (with solenoid and pneumatic actuator) as the case may be, discharge pipe, check valve and all other accessories required to make a complete operation system meeting applicable requirements of NFPA 2001 standards and installed in compliance with all applicable requirements of the local codes and standards.

The system design should be based on the specifications contained herein, NFPA 2001 and in accordance with the requirements specified in the design manual of the agent. The bidder shall confirm compliance to the above along with their bid.

The system shall be properly filled and supplied by a UL/ Vds listed OEM (Original Equipment Manufacturer) with UL/ PESCO/ listed filling plant.

Generally the key components of the system shall be UL/ Vds listed.

The NOVEC 1230/ FK-5-1-12 gas shall:

- I. comply with NFPA 2001 standard
- II. have the approval from US EPA (Environmental Protection Agency) for use as a total flooding fire extinguishing for the protection of occupied space:
- III. Underwriters' Laboratories Inc. (UL, USA) component listing for the NOVEC 1230/ FK-5-1-12 gaseous agent.
- IV. Must have zero ozone depletion potential (ODP)
- V. Must have a minimal life span in atmosphere, with atmospheric life time of less than 5 days
- VI. Be efficient, effective and does not require excess space and high pressure for storage.

The Cylinder Shall:

- I. PESO approval copy on Valve assembly
- II. PESO approval copy of Cylinder
- III. Contactable pressure gauge
- IV. Burst disc rated to 65 deg. rating

2.0 Design Condition

The Novec 1230/ FK-5-1-12 agent is stored in seamless steel cylinders and dry nitrogen is added to provide additional energy to give the required rapid discharge. At the normal operating pressure of 0 - 70 bar at 21 degree C, the agent is a liquid in the container.

- The designer shall consider simultaneous total flooding of all voids within the protected volume. The system shall be designed in accordance with the OEM's Design Manual.
- In order to extinguish a fire using clean agent, the concentration of agent delivered to each void shall be above the minimum design concentration. The following shall be considered while designing the system.
- The minimum design concentration shall be 4.5%. Class C Design concentration.
- If the protected volume has a floor and / or ceiling void the spaces shall be included in the protected volume, employing a minimum design concentration not below that of the main room compartment.
- The discharge nozzles shall be located within the protected volume in compliance to limitations and with regard to spacing, floor and ceiling coverage, etc. The nozzles shall be positioned such that they would cover the entire area up to the extreme corners of the area under protection and the design concentration will be established in all parts of the protected volumes.
- The final numbers of discharge nozzles shall be according to the OEM's product manual.
- The average pressure at each nozzle shall not be less than 6.00 Bar.
- The gas flow calculations shall be carried out on special software given by the OEM. The software should support usage of seamless cylinders which have a different design compared to the standard containers used worldwide. The system acceptance report shall show the resulting concentration in each independent void to be above 4.7% and the average pressure at each nozzle to be not less than 4.00 Bar.
- A fill density between 0.3 Kg/Lt to 0.9 Kg/Lt or as recommended by the manufacturer should be considered for the agent to be discharged within the specified time not exceeding 10 seconds and not less than 5 seconds.
- The design concentration shall follow at minimum NFPA 2001 for under floor, room and ceiling space. Unless otherwise approved, room temperature for airconditioned space shall be taken around 20 C. For non-air conditioned space, the temperature shall be taken around ambient temperature. The system shall be designed with minimum design concentration of 4.5 % as applicable to Class A & C fire.

The OEM should carry out the piping Isometric design and provide the hydraulic flow calculation results generated by using their UL/FM/ Vds listed design software.

The system shall be so designed that a fire condition in any one protected area shall actuate automatically the total flooding of clean agent in that area independently. The entire system shall incorporate inter-alia detection, audible and visual alarms, actuation and extinguishing.

3.0 SYSTEM DESIGN

All components offered by the OEM including the cylinders shall be UL/PESCO/FM/ Vds listed. The filling of the system shall take place in a UL/PESCO/LPCB listed filling plant owned by the OEM supplier.

3.1 Cylinders

Each cylinder shall be seamless steel type manufactured from billets and tested in accordance with DOT3AAA standards. The cylinders shall be UL/PESO listed for filling with Novec 1230/ FK-5-1-12 systems.

The cylinder/valve assembly shall have PESO/ Vds approval copies. The burst disc of the valve should be rated to 65 deg.

The cylinders shall be super-pressurized with dry Nitrogen to 70 bar. The cylinder shall be capable of withstanding any temperature between -10 Deg. C and 65 Deg. C.

All cylinders shall be distinctly and permanently marked with the quantity of agent contained, the empty cylinder weight, the pressurization pressure and the zones they are protecting.

3.2 Cylinder Valve

PESO approval copy on Valve is mandatory apart from PESO approval on cylinder. The document evidence for the same shall be produced during bidding.

The UL/ Vds listed valve shall be mounted directly on the cylinder and should

NOT have any adaptor provision between the cylinder and Valve

Each cylinder valve shall have a provision for fixing a UL listed supervisory pressure switch and a safety burst disc to protect the cylinder from over pressure. The UL/ Vds listed cylinder valve shall have a disabling plug to prevent accidental discharge of the valve during transportation and installation.

Each valve is to be fitted with a pressure gauge for monitoring pressure in the cylinder.

The master cylinder valve is to be released electrically which is performed by means of a solenoid valve arrangement. Pilot cylinder actuation and pyrotechnic devices shall not be accepted.

Each pilot and main cylinders should have provision to display the pressure and temperature of the respective cylinders. Provision to check and monitor the temperature and pressure of any individual cylinder remotely through secured gateway needs to be necessarily provided. This provision will help in taking precautionary measures on time in case the pressure within the cylinders goes up / down causing safety hazard to human as well as infrastructure.

3.3 Cylinder valve Actuators

In a single cylinder system the cylinder shall have a UL/ Vds listed solenoid operated actuator and manual actuator as a single component. Multi cylinder systems shall have the same fitted on to the master cylinder and pressure operated actuators fitted on each slave cylinder. All actuators shall be UL/PESCO/LPCB/ Vds listed and OEM make and locally manufactured actuators shall not be used.

3.4 Hoses

Each cylinder valve shall be provided with a plug in type UL/ Vds listed flexible rubber discharge hose of minimum 40/50mm size. Each hose shall be permanently marked with the test pressure and OEM's part number. Multi cylinder systems shall have an interconnect hose for each cylinder. All hoses shall be UL/PESCO/LPCB/ Vds listed and OEM make. Locally manufactured hoses shall not be used.

3.5 Manifold Check valve

The manifold shall be fabricated from ASTM A106 Schedule 40 seamless pipe and shall be independently threaded to the UL/PESCO/FM/ Vds listed check valve. The Manifold shall preferably be fabricated at site based on the shop drawing from the OEM.

3.6 Other Accessories

Electric Control Head, Pressure operated control head, Master Cylinder Adapter Kit, Flexible discharge hose, discharge Nozzles, and other required accessories shall be approved or listed for use with the clean agent.

All the gaskets, O-ring, sealant and other components shall be constructed of materials compatible with the clean agent.

The system should be engineered using hardware & accessories approved by the Engineering System Distributors of clean agent as mentioned in the list of approved makes. The Vendor shall submit the detailed data sheets of each component with the required part Nos and also the common system data sheet containing these parts with part Nos.

4.0 FIRST FILL, RE-FILLING AND MAINTENANCE

The filling plant shall be UL/PESO/FM listed and should be from the OEM only.

In case of any leakage or accidental discharge of the agent, the refilling shall take place from the UL/PESO listed filling plant only. The contractor should indicate the source of re-filling and the time that will be taken for re-filling and replacement.

5.0 PIPING AND FITTINGS

All existing piping network to be used. However manifold wherever need changes has to be changed based on scope of work.

6.0 Documentation

The vendor should prepare & submit the piping Isometric drawing and support the same with a hydraulic flow calculation generated by using the agent's design software. The calculations shall validate the fill density assumed by the bidder.

The vendor shall submit copies of the datasheets of the hardware used in the system.

The vendor shall also submit calculations to evidence the quantity of agent considered for the system.

The System Company should provide, as part of handing over, the as-built drawing, operation manual and maintenance manual. The as-built drawing shall exactly match the Isometric drawing submitted with the flow calculation prior to commencement of work.

The vendor must submit, along with the supply invoice, a certificate of authenticity, for the agent.

Vendor to submit copy of relevant approvals/test certificates of the offered items along with accessories and fittings.

Vendor to provide MSDS and Safety guidelines with respect to "Hazards to Personnel" and Environmental factors regarding its use as clean agent for firefighting purposes.

Supporting documents indicating the offered clean agent having zero Ozone Depletion Potential

The construction drawing and design calculation of the offered item Vendor to provide list of spares to be maintained including cost thereof

Vendor shall provide CD/manual/maintenance instruction book, depicting the use and application of the system

Vendor to submit third party inspection certificates along with all accessories as required under technical specifications

The design & the installation shall be certified by principal system supplier
Testing Procedure for Gas Based Fire Suppression System General
Prior to placing the completed system in service, the installation should be inspected and tested by qualified personnel to confirm that the system has been properly installed and will function as specified below.

- Conformance to System design.
- Suitability of piping, its correctness to project design, and its supports.
- Operating Sequences
- Suitable Hazard Environmental controls and Safety precautions and.
- Compliance with the norms of NFPA STD. 2001 and other applicable standards.

Piping

- Verify that pipe sizes and layout are as indicated on the project working drawings.
- Verify the piping supports and ensure the pipes are secured and restrained from the movement.
- After the installation after system piping is completed, and prior to the connection of the cylinders, accessories, nozzles etc., the discharge piping should be blown out and then Pressure tested for leakage. Plug or Cap all pipe outlets and apply 40 psi (3 bar) pressure with air for 10 minutes. At the end of 10 minutes, the pressure loss shall not exceed 20% of the test pressure. Under no conditions should water be used in testing.

Cylinders

- Inspect cylinders and ensure bracketing and cylinders are secure. Check pressure gauge and ensure pressure is correct for temperature at cylinder location.
- Check cylinder discharge bends and check valves for proper orientation, connection and tightness.
- Ensure that the cylinder operating components and auxiliary control devices are installed in accordance with the project drawing. All the required labeling as done on the cylinders

Nozzles

- Ensure each nozzle has an orifice drilled to suit the specific location and discharge flow requirements.
- Verify that nozzle locations and orifice sizes are as indicated in the project drawing.

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HVAC WORKS

6.1 SYSTEM DESIGN DATA

This description covers the proposed HVAC system for construction of Integrated Terminal Building, ATC Tower & Technical Block, Fire Station, & Service Yard at Ujjain.

1 Basis of Design

1.1. Location

Site Location : Ujjain-M.P. (India)

1.2. Air-Conditioning Design –

- a) Outdoor dry bulb temperature for Ujjain Airport for summer, monsoon and winter to be considered by EPC contractor as per ASHRAE and relevant IS code
- b) Outdoor wet bulb temperature for Ujjain Airport for summer, monsoon and winter to be considered by EPC contractor as per ASHRAE and relevant IS code.
- c) % RH (Humidity factor) for Ujjain Airport for summer, monsoon and winter to be considered by EPC contractor as per ASHRAE and relevant IS code.

26.1 Indoor Design Conditions

EPC contractor shall make all calculation as per below given inside condition;
However, the Air-conditioning system shall also be in line with GRIHA 5.

S. No.	Description	Temperature °C	Relative Humidity (Design Value)
1	Hall/Waiting area/ Check in counter & Security hold area	22± 1	55±5%
2	F &B and Retails	22± 1	55±5%
3	Office Space	22± 1	55±5%
4	Lounge	22± 1	55±5%
5	Corridor	22± 1	55±5%
6	UPS/ Battery Room & control rooms(if any)	22± 1	55±5%
7	Server Rooms	20±1	55±5%

Relative Humidity: No RH Control provided other than by virtue of cooling coil selected to limit RH to 55±5% at peak design cooling load.

26.2 Building Envelop: -

As per Architectural/ civil specification & structural glazing

26.3 Mechanical Ventilation: As per NBC-2016 amended upto date.

Following areas shall be provided with mechanical ventilation system &

pressurization system complete in compliance to NBC-2016/ Fire Authority. Min. Ventilation parameters for each of the areas shall be as follows: -

Area Description	Air Change Per Hour (ACPH)
Basement Ventilation	6 ACPH Normal Operation and 12 ACPH in case of Emergency (As per NBC 2016).
AC Plant & Pump Rooms	20
LT, HT Panel & Meter Room (ESS Room)	20
STP Room & Garbage Disposal	30
DG Room	CFM based on DG capacity & DG manufacturer recommendation
Services Tunnel Exhaust / Fresh Air	15
Smoke Exhaust of Public Areas above & below ground floor	12
Public Toilets	15
Pantry Exhaust	6
Store Exhaust / Fresh Air	6
Smoking Room Exhaust Air	30
F&B Exhaust Air	40
F&B Fresh Air	85% of exhaust
UPS Battery Room	CFM based on UPS capacity & As per manufacturer recommendation
CFT Parking in Fire Station	12 ACPH
Pressurization	
Lift Well Pressurization	Mechanically pressurized for maintaining 50 Pa as per NBC 2016 & Fire Authority.
Lift Lobby Pressurization	Mechanically pressurized for maintaining 25 to 30 Pa or naturally / cross ventilated as per NBC 2016 & Fire Authority
Staircase Pressurization	Mechanically pressurized for maintaining 50 Pa or naturally / cross ventilated as per NBC 2016 & Fire Authority

26.4 Design Parameters:

A. Water Cooled variable speed screw chiller.

Performance rating of the Water Cooled variable speed screw chiller shall be based

on the following design parameters:

- Chillers shall be variable speed screw water cooled chiller.
- Chiller Motors must be equipped with unit mounted VFDs and active harmonic filters to limit THDi level till 5 % at chiller source. THDi levels shall be displayed at main chiller control panel of AHF panel.
- Water cooled Chillers shall be with hermetic/semi hermetic/open, single/multiple compressors, Flooded/ Falling Film type chillers.
- Chiller shall be Factory Assembled and Tested – Eurovent / AHRI certified.
- Equipment shall meet or exceed minimum efficiency requirements as 5-star rating ASHRAE/ ISHRAE/ ECBC Standards.
- The total capacity of chillers shall **be 375 TR (3Nos x 125 TR) (2W +1S)**
- Minimum 5-star Rating to be considered as per ECBC.
- The chiller capacity shall be as per following parameters:
 - Chilled Water Leaving Temperature: 6.67 Deg. C
 - Chilled Water Entering Temperature: 12.2 Deg. C
 - Chiller Fouling Factor: 0.0005 FPS
 - Chiller Water Flow Rate: @2.4GPM / TR
 - Condenser Entering Temperature: 32.2 Deg. C
 - Condenser Leaving Temperature: 36.4 Deg. C
 - Condenser Fouling Factor: 0.001FPS
 - Condenser Water Flow Rate: @ 3GPM/TR
 - 5-star rating as per ECBC
 - Noise at 1 m as per AHRI 575, shall be less than 85dBA at all load (100% to 20%)
 - Chiller should operate without hot gas by pass/envelop stability control.
 - VFD shall be factory fitted unit mounted/Free Standing, liquid/Air cooled.
- Motors shall be energy efficient must conform to minimum IE-4 Class Efficiency.
- Full compatibility with BMS System.
- Both Working and Stand-by provisions for Chillers has to be considered. Minimum One Chiller shall be considered in addition to the no.

of chillers as per requirements.

Refrigerant of chiller shall be CFC free, zero ODP& as per ASHRAE safety classification of A1.

One no chiller shall be tested at following conditions-

4 # points testing (100%, 75%, 50% & 25%) at constant condenser entry temperature of deg F.

1 # for 4 hrs continuous operation of chiller at minimum condenser water temperature of 65 deg F, without tripping.

The tests shall be conducted at the manufacturer's factory where proper testing facilities are available and the test results shall be submitted to the Consultant Engineer for approval and clearance. Test bed should be AHRI certified. The design ambient condition should be simulated during the chiller performance test. Test shall be conducted as per tolerance defined by AHRI.

Design parameter for selection of Air Handling Unit and its components shall be: (Based on Good design practice)

Maximum face velocity across pre-filters & fine filters (as per CPWD 2017)	155 m/min (508.4 fpm)
Maximum face velocity across cooling coils (as per CPWD 2017)	155 m/min (508.4 fpm)
Maximum fan outlet velocity (as per CPWD 2017)	610 m/min (2001 fpm)
Maximum fan speed (a)upto and including 450 mm dia (b) above 450 mm dia	As per OEM
Maximum fan motor speed	As per OEM
Maximum noise level at a distance of 2 Mtr from Floor Mounted AHUs (as per CPWD 2017)	75 dBA

Piping shall be sized as per CPWD Guideline:

Maximum velocity	:	2.5 m/s (8.2 FPS)
Maximum friction	:	5m/100m (5 ft per 100 ft Run)

Design parameter for Duct design shall be as per CPWD Guideline:

Maximum flow velocity in main ducts for air conditioning	400 mtr / min
Maximum flow velocity in Branch ducts for air conditioning	250 mtr / min
Maximum velocity at supply air grilles/ diffuser	150 m/min
Maximum flow velocity in ducts for ventilation in utility building ventilation & toilet exhaust.	1.5 times of Main ducts of main & Branch ducts
Maximum friction	1cm WG/100 m run

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6.2 SYSTEM DESIGN (SCOPE OF WORK)

1. HVAC SYSTEM: -

- i. It is proposed to install the water-cooled central plant for terminal building. AC plant shall be located in service yard. Following equipment's shall be installed in AC plant room & nearby (capacities mentioned are minimum capacities).
 - 02 Nos. (1 Working +1 Standby) 170 TR (minimum capacity) water cooled screw chiller with VFD & AHF (2W+1S).
 - Chiller Motors must be equipped with unit mounted VFDs and active harmonic filters to limit THDi level till 5 % at chiller source. THDi levels shall be displayed at main chiller control panel of AHF panel
 - Refrigerant (No Chlorine CFC and HCFC free refrigerant) - R-134A / R1233zd (E) / R-1234ze (E) & R-514A
 - To ensure quality, guaranteed efficiency and performance in compliance with the specified conditions, at least one no. chiller shall be fully tested and witnessed by client/consultant representatives at AHRI certified test bed. Capacity, lkw/TR, fouling shall be simulated as per AHRI 550/590. Chiller capacity and performance shall be as per tolerance defined at AHRI at various loads.

One no chiller shall be tested at following conditions-

4 # points testing (100%, 75%, 50% & 25%) at constant condenser entry temperature of deg F.

1 # for 4 hrs continuous operation of chiller at minimum condenser water temperature of 65 deg F, without tripping.

The tests shall be conducted at the manufacturer's factory where proper testing facilities are available and the test results shall be submitted to the Consultant Engineer for approval and clearance. Test bed should be AHRI certified. The design ambient condition should be simulated during the chiller performance test. Test shall be conducted as per tolerance defined by AHRI.

- 2 Nos. Primary Chilled Water Pumps (1W+1S) with constant pumping system
- 2 Nos. Secondary Chilled Water Pumps (1W+1S) with variable speed pumping system
- 2 Nos. Constant Speed Condenser Water Pumps (1W+1S).
- 2 Nos. FRP Induced Draft Cooling Towers (1W+1S) with VFD.
- 1 no. Closed Type Expansion Tank with Pressurizing Unit.
- Air and Dirt Separator.
- Electrical Panel.
- Automatic Tube Cleaning System for Chiller Condensers.
- Electro-Chemical Treatment System (non-chemical system) for cooling towers.
- Chiller Plant Optimizer (CPO) at BMS room or at suitable location as finalized

by the Engineer-in-Charge.

- ii. Chilled water supply to all conditioned areas shall be with 2.4 USGPM/TR. All chilled water pumps and pipes shall be insulated. Chilled water shall be pumped through insulated chilled water pipes installed in ceiling spaces within plant room and adjoining areas.
- iii. All pumps motors shall be IE-4 rating.
- iv. The chilled water pipes shall be laid in underground service trench from service yard to airport terminal building. The distribution of chilled water pipes up-to AHUs will take place through various vertical shafts.
- v. Chiller plant optimizer shall be provided to optimize the total chiller plant room operation. The prime function of a chiller plant optimizer is to optimize the operation of chillers, chilled water pumps, cooling water pumps and cooling tower, to exactly meet building load during operation with minimum energy consumption.
- vi. Plant machinery in the plant room at ground level shall be placed on PCC/RCC foundation and provided with anti-vibratory supports. All foundations should be protected from mechanical damage by providing epoxy coated angle nosing. Seismic restraints requirement shall also be considered.
- vii. Floor drain channels and dedicated drain pipes in slope shall be provided within plant room space for effective disposal of waste water.
- viii. Closed Expansion tank with pressurized unit (pumps shall be N+1) along with air & dirt separator to be provided in chilled water line.
- ix. All the valves shall be minimum PN16 rated and suitable for chilled and condenser water applications. Insulation of valves in chilled water lines shall be the same as that of pipe.
- x. Chilled/ condenser water pipes of sizes 150 mm & below shall be M.S. 'C' class as per IS: 1239 and pipes size above 150 mm shall be welded black steel pipe heavy class as per IS: 3589, from minimum 6.35 mm thick M.S. Sheet for pipes upto 350 mm dia. and from minimum 7mm thick MS sheet for pipes of 400 mm dia and above.
- xi. Coupling joints shall be provided for chilled and condenser water piping for all areas as per technical specifications.
- xii. All areas will be normally served by floor mounted multiple air handling units (AHU) located within AHU rooms. However, ceiling mounted AHUs / fan coil units / hydronic cassette units shall be provided to serve individual / small spaces only.
- xiii. Most of the air handling units (AHU) rooms shall be located on mezzanine floor, supply & return air duct from respective floors shall be brought to the AHU via shaft. Each shaft shall be properly closed with fire sealant & the duct shall be provided with fire dampers. The placement of AHUs shall be such that, they remain close to the zone or space they serve.

- xiv. The large spaces with long open spans shall be provided with long distance throw jet nozzles, drum louvers, vertical air towers etc. Long throw air outlets provide good air coverage in large open areas having nominal throw value of 25-30 meter.
- xv. F&B/ Retail areas shall be catered through suitable capacity of ceiling suspended air handling units. These areas shall be provided with chilled water pipe connection with isolation valve only. The tenant will need to install suitable capacity of air-conditioning units along with necessary internal air distribution arrangements for air-conditioning purpose at the time of fit out. The retail, canteen and F&B areas AC units shall be provided with ultrasonic type BTU meters.
- xvi. Automatic controls viz. 2-way motorized self-balancing cum control valve with modulating type actuator and proportionate thermostat shall be provided in each AHU cooling & heating coil connections. When the indoor specified conditions are achieved, 2-way valve will regulate/stop the chilled/ hot water flow to AHU cooling/ heating coil, which in turn will reduce the RPM of chilled/ hot water pumps and un-load the compressor thus conserving energy.
- xvii. Motorized 2-way control valve for ON/OFF control for all the fan coil units (FCUs)/ hydronic cassette units shall be provided.
- xviii. Fresh air to be provided in all area of terminal building as per latest ASHRAE /ISHRAE/ NBC/CIBSE Guide A recommendation.
- xix. Demand control ventilation (DCV) system is proposed to install for fresh air system in terminal building.
- xx. All public areas shall be provided with air quality sensor (CO2 Sensor) so as to constantly monitor indoor air quality. These air quality sensors shall control the fresh air quantity by modulating the Airflow monitoring control station (AFMCS) at fresh air grille.
- xxi. Treated fresh air shall be fed to all the AHUs via VFD driven TFA units. Wherever possible, TFA units with heat recovery system shall be provided to recover energy from cooled air being exhausted to the atmosphere from toilets.
- xxii. The construction of TFA units / TFA units with heat recovery system shall be same as of AHUs as described above. TFA unit with heat recovery system shall be provided with heat recovery section with heat recovery wheel and direct drive backward curved aero foiled design plug fan with IE-4 motor for exhaust air. Also, in TFA units, minimum 8 rows deep cooling coil & minimum 2 row deep heating coil shall be provided. No. of rows of coils can be exceed as per load requirement and coil selection. Coils shall be AHRI certified.
- xxiii. Smoke/ Fire dampers with actuators shall be provided in accordance with ASHRAE/ NFPA within supply air ducts and return air ducts at AHU room wall crossings, at fire rated wall crossings, and at walls between adjoining fire zones. In case of fire these fire dampers will start working and to be hooked up to fire alarm system.
- xxiv. Sound attenuators shall be provided in air handling and ventilation system

where applicable, in order to maintain desired NC levels.

- xxv. For better indoor air quality and control of various bacteria, virus etc., Duct mounted UVGI along with coil mounted UVGI system in all AHUs to be provided.
- xxvi. Air-conditioned air shall be supplied to each area by using factory fitted GSS duct (Sizes and gauges as per IS standard & CPWD specification only) duly insulated, aluminium powder coated grills/ diffusers/ jet diffuser or nozzles/ drum louvers/ slot diffusers/ stainless steel-304/316 displacement/ totem diffuser. Site fabricated ducts shall be provided for critical pieces like connection pieces, collar pieces, reducers, offsets pieces etc.
- xxvii. Conditioned air will be supplied through insulated supply air duct. Return air will be brought back to the AHU through insulated duct / void space above the false ceiling.
- xxviii. Variable air volume system comprising of VAV boxes shall be provided in air-conditioned areas which are not regularly used such as conference rooms, meeting rooms, class room, training rooms etc. to regulate the air flow of AHUs.
- xxix. Chilled water piping shall be 2 pipe systems either cooling & heating to be provided. System shall be complete with electrical panel, cabling & earthing.
- xxx. Ultrasonic BTU meters shall be installed for each chiller at the entry and leaving points to measure the cooling generated by chillers.
- xxxi. Fix Finger of PBB/ Fixed link: - Chilled Water air-conditioning shall be done upto fix finger area of PBB by chilled water cassette units.
- xxxii. Complete HVAC work shall be in accordance to CPWD HVAC specification-2017.
- xxxiii. Air curtain shall be considered for door opening in vestibule areas.

Plant machinery in the plant room shall be placed on (based on OEM requirement) foundation with anti-vibratory supports is to be provided by the EPC CONTRACTOR. Foundations should be protected from mechanical damage by providing epoxy coated angle nosing. Floor drain channels and dedicated drain pipes in slope shall be provided within plant room space for effective disposal of waste water.

2. MECHANICAL VENTILATION & PRESSURIZATION SYSTEM: -

- i. It is proposed to install normal ventilation, emergency smoke extraction, fresh air and emergency fresh air fans for complete areas as per fire norms (NBC-2016), as per local fire authority & required air changes as per NBC 2016. ii. Normal fresh air & normal exhaust fan will run all the time under minimum air changes & emergency fans will start to run at the time of fire. iii. Complete terminal building shall propose to have smoke extraction system and fans shall be placed on roof/ wall/ ceiling as per required capacity.

- ii. Services room in utility block, terminal block etc. shall also have mechanical ventilation as per NBC-2016.
- iii. All axial fans shall be AMCA certified. In addition to this all Fire Rated fans will be UL/CE/BSEN12102-3; 2015 certified for operation in case of fire.
- iv. All axial fans shall be long casing as per selection & requirement.
- v. All emergency fans & pressurization shall be connected to fire alarm panel, so that in case of fire fans will start running automatically.
- vi. For general areas ventilation, cabinet fan section, propeller fans, inline fans etc. to be provided.
- vii. For STP, effective exhaust @ minimum 30ACPH with cabinet fan section consist of prefilter section (50mm thick_MERV-8), Activated Carbon filter section and chemical filter section and ozone generator to be provided.
- viii. For toilets in terminal building, cooled supply air from nearest AHU shall be provided.
- ix. Exhaust vents/ grills shall be provided over each urinal/WC/ basin.
- x. Factory fabricated GSS duct shall be provided for ventilation system.
- xi. Fire rated coating shall be applied over Duct (as per NBC 2016) used for Smoke extraction duct, kitchen extract, basement ventilation, pressurization).

Pantry, Toilet & Smoking Room Exhaust

Pantries, toilets & smoking room shall have mechanical ventilation system consisting of cabinet fan section, in-line fan, in-line cabinet & Propeller fan with exhaust duct & grills etc.

3. Designs, Drawings and technical submittal

- **After Award of the Work :**

On the basis of tender drawing, the EPC CONTRACTOR shall carry out detailed engineering and prepare detailed supporting calculation (Heat load calculation, ventilation and pressurization calculation, pump head calculation, static pressure calculation etc.) as per tender parameter, norms/ by law etc. and submit for approval along with 03 (Three) sets of drawing & technical submittal of item to be procured and shop drawings for the entire HVAC installations under this contract and proposed General Arrangement drawings for major equipments within 30 (Thirty) days for approval of AAI before proceeding with the work. He shall also furnish all clarifications and explanations as may be desired by AAI promptly for early finalization of the design.

The work to be executed as per approved shop drawings & technical submittal only.

- **On Completion of Work :**

The EPC CONTRACTOR shall submit 4 (four) sets of as built drawings and O & M manuals for HVAC System as detailed subsequent section(s) including MCC panels, Circuit Diagram, Manufacturers technical catalogues, detailed specification of items provided along with soft copy of As-built drawings copies of Test Certificates of all major equipments duly bound in neat and presentable booklet forms within 30 days of completion of the work.

The EPC CONTRACTOR shall furnish and install in the plant room a neatly typed set of operating instructions securely framed and glazed as per the directions of the Engineer.

EPC CONTRACTOR shall also provide training to AAI officials of complete installation.

4. Approval from local authorities etc.

It shall be the responsibility of the EPC CONTRACTOR to get the approval instages from the local authorities, where ever required. This shall be without any liability to the Engineer-in-charge. On successful completion of work, the EPC CONTRACTOR shall incorporate all changes as approved by the local authorities etc. that might have been effected during execution of the work.

The EPC CONTRACTOR shall also bring to the notice of the Engineer-in-charge any deviations from Local Fire Service/Building Bye Laws Norms and requirements in the systems that he shall install as well as architectural features that will affect approval from the local authority/Fire Service. No extra charges shall be paid on account of interaction with the local authority/Fire Service.

5. Coordination

The EPC Contractor shall be required to coordinate his activities with all other services such as Electrical, plumbing, fire and architectural, Civil (Interiors) etc.

6. Test on Completion

Tests on completion shall mean such tests as are prescribed in the specifications or have been mutually agreed to between the EPC Contractor and the department to be made before the plant is taken over. In case tests are not possible due to climatic conditions at the time of completion, the EPC Contractor shall be bound to carry out tests as prescribed thereafter at any time subsequent to the date of completion.

CPWD_HVAC-2017 specification- complete proforma of Appendix-F & G to be filled by EPC contractor and submit for approval to Engineer-In

charge.

7. Noise Control (As per NBC & CPWD):-

The entire work shall conform to sound engineering practice and shall cause minimum transmission of noise and vibration.

The permissible and acceptable noise level, aesthetics should be considered.

8. Quality Assurance, Inspection, Testing, adjusting, commissioning & balancing shall be as per CPWD_HVAC 2017 chapter 17 & NBC-2016.

9. Painting & Finishes and identification of services:- To be provided as per CPWD_HVAC 2017 & NBC-2016 & IS codes.

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6.3 VARIABLE SPEED SCREW WATER COOLED CHILLER

Type- Screw compressor shall be open/ semi-sealed/ totally sealed type. It shall be working on CFC and HCFC free refrigerant. The impeller shall be of shrouded design and made of cast aluminum alloy of high strength and protected against corrosion. This shall be statically and dynamically balanced and over speed tested to ensure vibration free operation. The impeller shaft or drive end of the gear shaft shall be connected with the motor through a flexible coupling in case of open design and rotor shaft in case of hermetic design. The compressor casing shall be of high strength ductile casting and of such design that servicing can be carried out without disturbing connections.

1. SCOPE

The scope of this section consists of but is not necessarily limited to the following:

- Manufacture and supply of screw chillers with associated motors, factory fitted / free standing VFD starter and accessories.
- All associated items herein to be supplied, delivered and installed.
- Assembly of chiller components including connection of cooler, condenser, motor, compressor, purge system for low pressure machine etc. into complete refrigeration machine.
- Provide manufacturer's factory representative's services, including coordination, and start-up and testing supervision.
- Testing (factory and field) start-up supervision, training and providing necessary documentation and tools for operation.
- Carrying out performance test run at factory.
- Chiller shall be selected to operate from 100 to 25% load at constant condenser entry temperature & (design+5deg F) without surging and hot gas bypass & envelop stability control. AHRI certified and signed sheets shall be submitted by EPC contractor for the same. Performance sheet shall include all losses associated with factory fitted / free standing VFD and active harmonic filters etc.

2. QUALITY ASSURANCE PROGRAMME

a) Chiller shall be rated in accordance with Parameters indicated in technical specification and DBR. Pressure vessels shall be designed, constructed, tested, stamped and shall be complete with safety devices in accordance with ANSI/ASHRAE 15-1989 Safety Code and ASME/ PED/ BIS Code.

b) The chiller shall be designed/manufactured and tested in accordance with the applicable portions of the latest revisions of the following Standards and Codes.

ARI 550 / 590 – 2013	-	Performance rating of water chilling packages using the vapor compression cycle.
ARI 575	-	Air Conditioning and Refrigeration Institute. Standard Method of Measuring Machinery Sound Within Equipment Rooms (Basis of all data presented or field testing of equipment, with relation to sound requirements).
ASME CODE	-	American Society of Mechanical Engineers. (Div. 1 Code for Unfired Pressure Vessels - Section VIII, Design, construction, testing and certification of pressure vessels).

ANSI-B9.1	-	American National Standards Institute. Safety Code for Mechanical Refrigeration (overall general safety requirements, relief device sizing, etc.)
ANSI-B31.5	-	American National Standards Institute. Code for Refrigerant Piping.
TEMA	-	Tubular Exchanger Manufacturer's Association.
ISO R281	-	Rolling Bearings – Dynamic Load Ratings and Rating Life
AHRI standards	-	Chiller testing code
PED /ASME /BIS	-	European / British pressure vessel code

3. CAPACITY

There shall be a total of **03 nos. chillers having minimum capacity of 125 TR each (2 Working + 1 Standby)**. However, the actual refrigeration capacity of chilling machine shall be worked out by the EPC contractor after detailed engineering.

4. SCREW COMPRESSOR

The screw compressor shall have a rotary mono/ twin screw and may be of open/ Semi-sealed / totally (hermetic) sealed type. It shall be using only CFC and HCFC free refrigerant.

The screw compressor shall be preferably variable speed. The variable speed compressor shall have factory mounted / free standing variable speed drive.

The mono/ twin rotary screw shall be manufactured from forged steel. The profile of screws shall permit safe operation up to a speed of 3000 RPM for 50 Hz operation. The compressor shall unload from fully loaded to the minimum capacity by means of hydraulically actuated slide valve positioned over the screw rotor/ pilot operated solenoid valve & VFD.

The compressor housing shall be of high-grade cast iron, machined with precision, to provide a very close tolerance between the rotor(s) and the housing.

The rotor(s) shall be mounted on antifriction bearings designed to reduce friction and power input. There shall be multiple cylindrical bearings to handle the radial and axial loads.

There shall be built in oil reservoir to ensure full supply of lubricants to all bearings and a check valve to prevent backspin during shut down.

There shall be an oil pump or other means of differential pressure inside the compressor for forced lubrication of all parts during startup, running and during shut down. An oil sump heater shall be provided in the casing.

The open type of compressor shall also have a suitable shaft seal, to prevent leakage of refrigerant.

The units shall be complete with an automatic capacity control mechanism, to permit modulation between 25% to 100% of capacity range.

Interlocking

The compressor motor shall be interlocked with the following: -

Differential pressure switch in the chilled water line(s) in case of chilled water system, and air flow switch in the evaporator fan discharge in the case of direct expansion system.

Differential pressure switch in the condenser water line(s) in case of water-cooled condenser and air flow switch in the condenser fan discharge in the case of air cooled condenser.

Anti-freeze thermostat in case of chiller.

Condenser water pump in case of water-cooled condenser and condenser fan in case of air cooled condenser.

Chilled water pump in case of chilled water system and evaporator fan in case of direct expansion system.

The interlocks shall be provided with indicating lamps or flags in the control panel in the refrigeration plant room.

The driving motor shall be double squirrel cage type or suitable hermetic/ Semi hermetic/ open type as required, protected against damage by means of built in protection devices.

Compressor motor and starters

The electrical motor driving the compressor shall be squirrel cage induction motor class `F' insulation, fan cooled for open type unit; and totally enclosed, (refrigerant cooled) for hermetic/ semi-hermetic unit. The motor shall be suitable for operation on 415 + 10% volts, 3 phase, 50 HZ alternating current supply, unless otherwise specified. The motor synchronous speed shall not exceed 1500 rpm.

For open type compressor, the continuous B.H.P. rating of the motor shall be at least 110% of the maximum power requirement of compressor and drive under specified design conditions.

Its synchronous speed, however, shall be 3000 RPM. All compressor motors in screw chillers shall be provided with VFD wherever feasible.

Compressor Motor overloads capable of monitoring compressor motor current. Provides extra protection against compressor reverse rotation, phase-loss and phase-imbalance.

Motor Starters: Motor starters shall be zero electrical inrush current (Variable Frequency Drives) or reduced inrush type (Closed transition Star-Delta or Solid State) for minimum electrical inrush. Open transition Star-Delta and Across the Line type starters will not be acceptable.

Power factor correction capacitors as required to maintain a displacement power factor of 95% at all load conditions shall be provided.

Controls

General:

Provide automatic control of chiller operation including compressor start/ stop and load/ unload, anti-recycle timer, evaporator pump, condenser pump, evaporator heater, condenser heater, unit alarm contacts and run signal contacts.

Chiller shall automatically reset to normal chiller operation after power failure.

Unit operating software shall be stored in non-volatile memory. Field programmed set points shall be retained in lithium battery backed regulated time clock (RTC) memory for minimum 5 years.

Alarm controls shall be provided to remote alert for any unit or system safety fault.

Display and Keypad:

Provide minimum 80-character liquid crystal display that is both viewable in direct sunlight and has LED backlighting for nighttime viewing. Provide one keypad and display panel per chiller.

Display and keypad shall be accessible without opening main control/electrical cabinet doors.

Display shall provide a minimum of unit setpoints, status, electrical data, temperature data, pressures, safety lockouts and diagnostics without the use of a coded display.

Descriptions in English (or available language options), numeric data in English (or Metric) units.

Sealed keypad shall include unit On/ Off switch.

Programmable Setpoints (within Manufacturer limits): Display language, chilled liquid cooling mode, local/ remote control mode, display unit mode, system lead/lag control mode, remote temperature reset, remote current limit, remote heat recovery kit, leaving chilled liquid setpoint and range, maximum remote temperature reset.

Display Data:

Chilled liquid leaving and entering temperatures; lead system; flow switch status; evaporator/condenser pump status; active remote control; evaporator pressure, discharge, and oil pressures, condenser and economizer pressures per refrigerant circuit; economizer

temperature and superheat; sub cooler liquid temperature and superheat; compressor discharge temperature and superheat, motor; temperatures, educator temperature, per refrigerant circuit; compressor speed, condenser level, condenser level control valve; economizer superheat; economizer feed valve percentage open, evaporator/ condenser heater status; oil pump status; compressor number of starts; run time; operating hours; evaporator and condenser heater status; history data for last ten shutdown faults; history data for last 20 normal (non-fault) shutdowns.

Predictive Control Points:

Unit controls shall avoid safety shutdown when operating outside design conditions by optimizing the chiller controls and cooling load output to stay online and avoid safety limits being reached. The system shall monitor the following parameters and maintain the maximum cooling output possible without shutdown of the equipment: motor current, evaporator pressure, condenser pressure, discharge pressure, starter internal ambient temperature, and starter baseplate temperature.

System Safeties:

Shall cause individual compressor systems to perform auto-reset shut down if: high discharge pressure or temperature, low evaporator pressure, low motor current, high/low differential oil pressure, low oil level, low discharge and economizer superheat, smart freeze point protection, high motor temperature, system control voltage, educator clog.

Unit Safeties:

Shall be automatic reset and cause compressors to shut down if: low leaving chilled liquid temperature, under voltage, flow switch operation. Contractor shall provide flow switch and wiring per chiller manufacturer requirements.

Manufacturer shall provide any controls not listed above, necessary for automatic chiller operation. Mechanical Contractor shall provide field control wiring necessary to interface sensors to the chiller control system.

Bearings

The compressor shall incorporate the necessary design features which eliminate both the axial and radial thrust. The bearings shall be pressure lubricated during operation and shall be completely sequenced and interlocked with the startup of the machine in such a way that the oil pump should start earlier than the machine and the machine should automatically start after some time provided the oil temperature and pressure is maintained during the start-up period. On stopping the machine, oil pump should stop only after the machine has completely stopped.

Lubrication System

The lubrication system shall form one integral part of the compressor assembly and shall enforce complete force feed lubrication (at a controlled pressure and controlled temperature) to all bearing surfaces under any speed conditions, at start-up, at shut down and during operation at various loads. Provision shall also be made to take care of lubrication during coast down cycle upon intermittent failure of power. Thus full lubrication must be available to the machine during acceleration and deceleration periods. Further it should include the following:

- i) VSD Oil Pump
- ii) High efficiency oil filters.
- iii) Low oil pressure cutout.
- iv) Oil coolers and oil heaters (with built-in-thermostat) to aid maintaining constant temperature.
- v) Oil level indicator.
- vi) Oil pressure control with pressure gauges and thermometer.

The compressor shaft seal shall consist of a spring loaded precision carbon ring high temperature elastomer "O" ring static seal and stress relieved precision lapped collars. The seal must effectively prevent the leakage of refrigerant along the shaft during shut down periods. During operation an oil film under pressure should prevent outward leakage of refrigerant. Oil cooler shall be refrigerant cooled factory fitted and shall be in built part of chiller package. Oil cooler shall be shell & tube / PHE type. Condensed liquid refrigerant/chilled water shall be used for oil cooling purpose.

Capacity Control

The compressor shall be equipped for modulating the capacity from 100% up to the 25% at constant condenser entering water temperature without surging and hot gas bypass. The pre rotation vanes located at the impeller inlet for controlling the capacity shall be

aerofoil shaped and shall be made as per manufacturer's standard. The vane position shall be controlled through hydraulic/ linkage system.

The positioning of the vane shall be through microprocessor-based controller with its sensing elements in the outgoing chilled water lines. The automatic damper will enable maintenance of specified chilled water temperature within ± 0.11 deg C.

The compressor shall be equipped with an automatic suction damper or inlet guide vanes control for regulating its capacity. The positioning of the damper shall be done by means of thermostatically actuated electronic temperature-controller differential-type with its sensing element or elements in the outgoing chilled water lines. The automatic damper will maintain the constant temperature of chilled water. It should be possible to go down to 25% of full load at constant condenser entering water temperature without hot gas bypass and surging as per ARI 550/590-2013 with linear reduction in power input to the chilling machine.

Compressor and motor sole plates, anchor bolts and sleeves and necessary vibration isolation pads shall be included.

Microprocessor Control Centre

Each unit shall be furnished with microprocessor control centre in a locked enclosure, factory mounted, wired and tested. The control centre shall include larger HMI graphical display showing all system parameters in English language with numeric data in English (FPS) units.

Digital programming of essential set points through a color coded, tactile-feel keypad shall include: entering and leaving chilled water temperature and condensing water temperature; percent loading; pull-down demand limiting; seven-day time clock for starting and stopping chiller (complete with local holiday schedule); and remote reset temperature range.

All safety and cycling shutdowns shall be annunciating through the graphical display and consist of day, time, cause of shutdown, and type of restart required. Safety shutdowns shall include: high oil pressure; high compressor discharge temperature; low evaporator pressure; motor controller fault; and sensor malfunction. Cycling shutdowns shall include: low water temperature; low oil temperature; chiller/condenser water flow interruption; power fault; internal time clock; and anti-recycle.

System operating information shall include: return/leaving chilled water temperatures; return/leaving condenser water temperatures; evaporator /condenser refrigerant pressure; differential oil pressure; percent motor current; evaporator/condenser saturation temperatures; guide vane position, operating hours (Hours Run) and number of compressor starts, purge unit operation, compressor motor current and fault history.

Security access shall be provided to prevent unauthorized change of set points to allow local or remote control of the chiller and to allow manual operation of the pre rotation vanes and oil pump.

The chiller shall be provided with an RS-232/485 port to output all system operating data, shutdown/cycling messages and a record of the last four cycling or safety shutdowns to a remote printer or Building Automation System (BAS). The control center shall be programmable to provide data logs to the BAS/printer at a set time interval.

The chiller control panel shall be able to interface with the Building Automation System (BAS) to provide remote chiller start/stop, reset of chilled water temperature, reset of current limit; and status messages indicating chiller is ready to start, chiller is operating, chiller is shut down on a safety requiring reset, and chiller is shut down on a recycling safety. Control panel should be with open protocol like Modbus RTU / Bacnet / Lon work etc. for integrating with BAS.

INTERFACE WITH BUILDING AUTOMATION SYSTEM

All necessary hardware's (BMS card) / software's to integrate the chiller panel to BAS system shall be provided free of cost by the EPC Contractor.

For the integration of Microprocessor Panel of the chilling machine with the Building Automation System, an Interface Control system as required shall be developed and provided by EPC Contractor.

CONTROL CONSOLE

The chiller shall be controlled by a stand-alone microprocessor based control centre. The chiller control panel shall provide control of chiller operation and monitoring of chiller sensors, actuators, relays and switches.

The chiller control panel shall also provide:

1. System operating information including:

- i) return and leaving chilled water temperature
- ii) return and leaving condenser water temperature
- iii) evaporator and condenser saturation temperature
- iv) differential oil pressure
- v) percent motor current
- vi) evaporator and condenser saturation temperature
- vii) compressor discharge temperature
- viii) oil reservoir temperature
- ix) compressor thrust bearing positioning and oil temperature
- x) operating hours
- xi) number of compressor starts

2. Digital programming of setpoints through the universal keypad including:

- i) leaving chilled water temperature
- ii) percent current limit
- iii) pull-down demand limiting
- iv) six-week schedule for starting and stopping the chiller, pumps and tower
- v) remote reset temperature range

3. Status messages indicating:

- i) system ready to start
- ii) system running
- iii) system coast down
- iv) system safety shutdown-manual restart
- v) system cycling shutdown-auto restart
- vi) system pre-lube
- vii) start inhibit

4. The text displayed within the system status and system details field shall be displayed as a color coded message to indicate severity: red for safety fault, orange for cycling faults, yellow for warnings, and green for normal messages.

5. Safety shutdowns enunciated through the display and the status bar, and consist of system status, system details, day, time, cause of shutdown, and type of restart required. Safety shutdowns with a fixed speed drive shall include:

- i) evaporator – low pressure
- ii) evaporator – transducer or leaving liquid probe
- iii) evaporator – transducer or temperature sensor
- iv) condenser – high pressure contacts open

- v) condenser – high pressure
- vi) condenser – pressure transducer out of range
- vii) auxiliary safety – contacts closed
- viii) discharge – high temperature
- ix) discharge – low temperature
- x) oil – high temperature
- xi) oil – low differential pressure
- xii) oil – high differential pressure
- xiii) oil – sump pressure transducer out of range
- xiv) oil – differential pressure calibration
- xv) oil – variable speed pump – pressure setpoint not achieved
- xvi) control panel – power failure
- xvii) motor or starter – current imbalance
- xviii) thrust bearing – proximity probe clearance
- xix) thrust bearing - proximity probe out – of – range
- xx) thrust bearing – high oil temperature
- xxi) thrust bearing – oil temperature sensor
- xxii) watchdog – software reboot

5.1 Safety shutdowns with a VSD Shall include:

- i) VSD shutdown – requesting fault data
- ii) VSD – stop contacts open
- iii) VSD – 110 % motor current overload
- iv) VSD – high phase A, B, C inverter heat-sink temp.
- v) VSD – high converter heat-sink temperature

6. Cycling shutdowns enunciated through the display and the status bar, and consists of system status, system details, day, time, cause of shutdown, and type of restart required. Cycling shutdowns with a fixed speed drive shall include:

- i) multiunit cycling – contacts open
- ii) system cycling - contacts open
- iii) oil – low temperature differential
- iv) oil – low temperature
- v) control panel - power failure
- vi) leaving chilled liquid - low temperature
- vii) leaving chilled liquid - flow switch open
- viii) motor controller – contacts open
- ix) motor controller – loss of current
- x) power fault
- xi) control panel - schedule
- xii) starter – low supply line voltage
- xiii) starter – high supply line voltage
- xiv) proximity probe – low supply voltage
- xv) oil - variable speed pump - drive contacts open

6.1 Cycling shutdowns with a VSD shall include:

- i) VSD shutdown – requesting fault data
- ii) VSD – stop contacts open

- iii) VSD initialization failed
- iv) VSD - high phase A,B,C instantaneous current
- v) VSD – phase A,B,C gate driver
- vi) VSD – single phase input power
- vii) VSD – high DC bus voltage
- viii) VSD – pre charge DC bus voltage imbalance
- ix) VSD – high internal ambient temperature
- x) VSD – invalid current scale selection
- xi) VSD – low phase A, B, C inverter heatsink temp.
- xii) VSD – low converter heatsink temperature
- xiii) VSD – pre-charge - low DC bus voltage
- xiv) VSD – logic board processor
- xv) VSD – run signal
- xvi) VSD – serial communications

EVAPORATOR AND CONDENSER

a) Shells and Water Boxes

The evaporator and condenser shells shall be ASME/ PED/ BIS stamped of rolled carbon steel (MS) plate with fusion welded seams. Removable compact water boxes of cast iron or welded steel with stub-out water connections shall be provided on condenser side to permit access for tube cleaning and replacement. The tubes shall be finned from outside having spiral ridges from inside, roller expanded into the tube sheets providing a leak proof seal. The tube material will be copper. Intermediate tube supports should be provided at intervals not exceeding 1200 mm.

b) Evaporator (Chiller)

Chiller shall be provided with eliminator to prevent liquid carry over to the compressor. The chiller shall be provided with a relief valve or rupture disc of the bursting type to prevent excess pressure in the heat exchanger. The chiller shall be horizontal, shell and tube type, provided with the following connections and accessories:

- i) Refrigerant inlet and outlet pressure gauges.
- ii) Water inlet and outlet connections.
- iii) Drain and vent connections with stop valves.
- iv) Descaling valves.

Chiller shall be factory insulated with 19 mm thick nitrile rubber / or equivalent thermal insulation as per manufacturers standard with vapour barrier, thermal insulation material. The insulation shall be applied in such a manner that water boxes and covers shall be removable without damaging it.

c) Condenser

The condenser shall be horizontal, shell and tube type. The condenser shall be complete with the following accessories:

- i) Refrigerant inlet and outlet pressure gauges.
- ii) Water inlet and outlet connections.
- iii) Drain and vent connections with stop valves.
- iv) Descaling valves.
- v) Purge unit

d) Expansion Valve

Liquid flow to evaporator shall be metered through electronic expansion valve.

INSTALLATION

The chilling machine shall be installed over a cement concrete platform and shall be adequately isolated as per manufacturers recommendations against transmission of vibrations to the building structure. For open type, special attention shall be paid to the alignment of the drive and driven shafts; final alignment shall be checked at site in presence of the Owner's site representative, using a dial indicator. Compressor and motor sole plates, anchor bolts and sleeves and necessary vibration isolation pads shall be included.

PAINTING

Screw water chilling machine shall be finished with durable enamel paint. Shop coats of paint that have become marred during shipment or erection, shall be cleaned off with mineral spirits, wire brushed, and spot primed over the affected areas, then coated with enamel paint to match the finish over the adjoining shop-painted surface.

PERFORMANCE RATING

The unit shall be selected for the 75dB operating noise level at 3-meter distance. Capacity ratings and power consumption with operating points clearly indicated, shall be submitted and verified at the time of testing and commissioning of the installation. Capacity shall be ascertained by measurements of chilled water flow rate and temperature of chilled water in and out of the chilling unit. Power consumption shall be computed from measurements of incoming voltage & input current to the chilling machine.

WITNESS TEST

Prior to shipment, 1 no. randomly selected Chilling machine shall be subject to inspection and witness of performance tests by AAI representatives to check unloading of chiller at 4 points (100%, 75%, 50%, 25%) at tender condition.

In addition to above, 4 point testing (100%, 75%, 50%, 25%) shall also be carried out to verify COP and IPLV at AHRI condition. Complete testing and tolerance shall be as per as per AHRI – 550 / 590 standards.

All performance parameter shall be inclusive of all losses associated with VFD and active harmonic filter losses. Tolerance allowed as per AHRI standard is permissible during performance testing and manufacturer's factory.

HARMONIC FILTRATION

The chillers / chiller switchboard shall be equipped with active harmonic filtration (UL Listed) to filter any harmonics generated from the Chiller plant. Harmonic filter to limit THDI to 5% at equipment level.

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TITLE WATER COOLED CHILLER PACKAGE – DATA SHEET A		
S. No.	Description	Requirement
1.	Number Required	2 (1W+1S)
2.	Location	As per drawing
3.	Duty:-	Continuous
4.	Capacity required at specified design conditions per chilling package	170 TR Capacity(Minimum)
5.	Refrigerant (No Chlorine CFC and HCFC free refrigerant)	R-134A / R1233zd (E) / R-1234ze (E)& R-514A
6.	Maximum noise level at a distance of 1 meters as per AHRI 575	85 dBA
7.	Compressor – type	Semi-hermetic/ hermetic/ Open/ Screw compressor
8.	Lubrication	Forced feed with an oil pump/ differential pressure
9.	Capacity control	Automatic
10.	EVAPORATOR	
10.1	Type	Shell and tube, flooded
10.2	Liquid to be cooled	Water
10.3	Chilled water quality	Potable water
10.4	Chilled water inlet temperature	12.2 Deg C
10.5	Chilled water outlet temperature	6.67 Deg C
10.6	Minimum chilled water flow per chilling package	@2.4 USGPM /TR
10.7	Fouling factor-water side (FPS unit)	0.0005
10.8	Chiller and suction line insulation	25 mm Closed cellpolyvinylchl
10.9	Maximum water side pressure drop	10m of water
11.	CONDENSER	
11.1	Type	Water cooled, Shell and tube
11.2	Liquid to be cooled	Water
11.3	Condenser water quality	Potable water
11.4	Condenser water inlet temperature	32.2 Deg C
11.5	Condenser water outlet temperature	36.4Deg C
11.6	Minimum chilled water flow per chilling package	@3 USGPM/TR
11.7	Fouling factor-water side (FPS unit)	0.001
11.8	Maximum water side pressure drop	10m of water
12.	Motor	415 V +/- 10%, 3 phase, 50 Hz

13.	Control Panel	Microprocessor based control panel
14.	Control panel to be interfaced with building automation system	BMS Card to be provided by chiller vendor
15.	Type of starter	Unit mounted VFD/Floor Standing with active harmonic filter maximum THID of 5% at chiller source
16.	Type Refrigerant	Refrigerant (No Chlorine CFC and HCFC free refrigerant) - R-134A / R1233zd (E) / R-1234ze (E) & R-514A
17.	Rating	5 star

CHILLER PACKAGE -DETAILS TO BE FURNISHED BY TENDERER			– DATA SHEET B
S. No.	Description		Tenderer to Furnish
1.0		Water Cooled Chilling Unit	
		General Data	
	1.1	Number of chillers	
	1.2	Location	
	1.3	Make and country of origin	
	1.4	Model number and year of introduction model from same factory	
	1.5	Detailed list of installations of that model in India from same factory	
2.0		Operating Parameters	
	2.1	Minimum refrigeration capacity (TR)	
	2.2	Minimum chilled water flow rate (USGPM)	
	2.3	Maximum chiller pressure drop (Feet of water)	
	2.4	Entering chilled water temperature (deg F)	
	2.5	Leaving chilled water temperature (deg F)	
	2.6	Evaporating temperature (deg F)	
	2.7	Fouling factor for chiller	
	2.8	KW/TR at full load conditions	
	2.9	Entering Condenser water temperature (deg F)	
	2.10	Leaving condenser water temperature (degF)	
	2.11	Fouling factor for condenser	
3.0		Compressor	
	3.1	Manufacturer	

	3.2	Model	
	3.3	Type of compressor	
	3.4	Speed (operating)	
	3.5	Speed (maximum)	
	3.6	Refrigerant used	
4.0		Evaporator	
	4.1	Manufacturer	
	4.2	Model (No)	
	4.3	Shell dia. (mm)	
	4.4	Tube length (m)	
	4.5	No of tubes (No.)	
	4.6	Material of tubes (Name)	
	4.7	Dia. of tubes (mm)	
	4.8	No of integral fins / cm (No.)	
	4.9	No of refrigerant circuits (No.)	
	4.10	No of water passes (No.)	
5.0		Compressor Motor	
	5.1	Manufacturer	
	5.2	Type	
	5.3	Motor Voltage	
	5.4	Rated output	
	5.5	Power characteristics	
	5.6	No of Motors	
6.0		Starter for Compressor Motor	
	6.1	Manufacturer	
	6.2	Type of starter	
	6.3	Active Harmonic Filters wiyh THDI at chiller source (must be < 5% (Yes or No)	
	6.4	Hot gas by pass/Environment stability control (Yes/No)	
7.0		Miscellaneous Details	
	7.1	Type of capacity control	
	7.2	for loads	
	7.3	Equipments size (LXBXH)	
	7.4	Equipments operating weight (kg) / pounds	
	7.5	Full refrigerant charge quantity	
8.0		Documents to be furnished with bid.	

	8.1	Computerized printout (AHRI certified) from chiller manufacturer (without hot gas by pass/environment stability control) indicating power consumption in IKW/TR at full load and 75%, 50% & 25% conditions as per AHRI reducing ECWT full load and 75%, 50% & 20% conditions as per constant ECWT of 89.2 deg F	
	8.2	Catalogues furnishing detailed technical data for compressor, evaporator, condenser, VFD with active harmonic filter microprocessor or micro-computer control panel etc.	

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6.4 PUMPS

1. **SCOPE:**

The scope of this section comprises the supply, erection, testing and commissioning of water pumps conforming to these specifications and in accordance with system and design requirements.

2. **TYPE:**

All water pumps, for air conditioning applications shall be of approved make. The equipment shall be capable of developing the required total head at rated capacity. The pumps shall be suitable for parallel operation and should not overload in single pump operation. The pumps shall run smooth without undue noise and vibration. **The efficiency of chilled water pumps shall be as per GRIHA 5 Star requirement.**

3. **SPLIT COUPLED TYPE VERTICAL INLINE PRIMARY/ SECONDARY/ CONDENSER PUMPS**

The pump sets shall be vertical inline long coupled with suction and discharge flanged connections coupled with totally enclosed fan cooled squirrel cage induction motor and suitable starter as specified.

a) Pump casing shall be close-grained cast iron of heavy section, vertically inline split coupled/ long coupled pump, making possible complete servicing of rotating parts without breaking piping or motor connections. Motor to pump connection shall be of the rigid steel coupling type. The seal shall be outside type mechanical seal. Inside/ Unitized type seal shall not be considered for selection. Suction passages shall be volute in form, promoting smooth entry to impeller and increased efficiency. Impeller shall be bronze/Equi, suction, enclosed type, hydraulically balanced and passages smooth-finished for minimum friction and maximum efficiency. Impeller rings shall be secured from relative movement by tongue and groove fittings. Shaft shall be steel. Shaft shall be supported in ball /journal bearings, grease lubricated if applicable, contained in easily removable housing. Pumps shall be fitted with outside type mechanical seals, an air valve, drain plug and water seal drain connections. Pump shall be PN-16 rated

b) Motor shall be energy efficient (IE-4) totally enclosed, fan-cooled, Class-F insulation. Motor shall be specially designed for quiet operation. The motor rating shall be such as to ensure non overloading of the motor throughout its capacity range. Motor shall be suitable for $415 \pm 10\%$ volts, 3 phase, 50 cycles AC, power supply.

c) Installation: The pump & motor shall be installed on a common mild steel base frame grouted to concrete foundation with isolation vibrator (or as per OEM requirement).

d) The centrifugal pump shall confirm to IS 1620/ Equip. The motor for chilled water pump shall be suitable for use with VFD/ VSD.

4. LUBRICATION:

Upon installation of the complete system and before testing, the pump shall be lubricated in strict accordance with the manufacturer's instructions.

5. PUMP ALIGNMENT:

All pumps prior to testing shall be aligned with a dial indicator within 0.05mm.

6. PAINTING:

All pumps, motors and bases shall be supplied with approved finish. Shop coat of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the adjoining areas.

7. PERFORMANCE DATA:

Pump performance curves and power consumption with operating points clearly indicated shall be submitted, and verified at the time of testing and commissioning of the installation.

8. VIBRATION ISOLATION PADS:

Isolation Pad for Pump foundation is to be provided as applicable in the supports provided for VIL pumps. VI pads shall be serrated rubber pads and shall be provided in two layers with G.I sheet sandwiched in between. The same is applicable as per pump construction and OEM stds.

9. TESTS AND INSPECTION Field Testing

Pump performance shall be computed from the pump curves provided by manufacturer. All pumps shall be tested at factory as per relevant standards & codes. The software selections for all the pumps shall be provided.

Drawings

The following drawings shall be submitted by the EPC CONTRACTOR after award of work:

Preliminary outline dimensional drawing of pump and motor (Suction and discharge connections and foundation details shall also be indicated).

Performance curves (capacity vs total head, efficiency, NPSH and KW requirement) ranging from zero to maximum capacity.

Pump Catalogues.

Pump Head Calculation

It is very important that EPC CONTRACTOR shall submit actual pump head calculation based on site installation conditions taking into account pressure drop in installed (to be installed) chillers, piping and fitting. This actual pump head calculation shall be submitted for Engineer-In-charge for approval before ordering equipment and motor.

Required pump motor capacity will be provided based on actual head calculation without any extra cost.

VARIABLE SPEED PUMPING SYSTEM

Scope

The scope of this section comprise the supply, erection, testing and commissioning of variable speed pumping package consisting of following:

- a) Individual Components
- b) Pump Control Panel
- c) Pump logic Controller
- d) Variable Frequency Drive / Variable Speed Drive which displays Head and flow and shall be integrated/ mounted on the pump.
- e) Differential pressure transmitter / Sensorless pumps
- f) Logic Programming for sequence of Operation
- g) Power wiring and control wiring shall be carried out by installation EPC CONTRACTOR as shown on the field connection drawings and wiring diagrams supplied with the pumping package.
- h) Commissioning.

References

- | | | |
|----|------|---|
| a) | IS | Indian Standard |
| b) | ANSI | American National Standards Institute |
| c) | NEMA | National Electrical Manufacturers Association |
| d) | UL | Underwriters Laboratories Inc. |
| e) | ETL | Electrical Testing Laboratories |
| f) | CSA | Canadian Standards Association |
| g) | NEC | National Electrical Code |
| h) | ISO | International Standards Organization |
| i) | IEC | International Electrochemical Commission |
| j) | HI | Hydraulic Institute standards for pumps |

Submittals

Following shall be submitted for approval of AAI before procurement.

- a) System summary sheet.
- b) Sequence of operation
- c) Shop drawings indicating dimensions, required clearances and location and size of each field connection.
- d) Power and control wiring diagrams.
- e) System profile analysis including variable speed pump curves and system curve. The analysis shall also include pump, motor and variable Frequency Drive (VFD) efficiencies, job specific load profile, staging points, and horse power and kilowatt/hour consumption.
- f) Pump data sheets.

Quality Assurance

- a) The pumping package shall be assembled by the pump manufacturer.
- b) All functions of the variable speed pump control system shall be tested at the factory prior to shipment. This test shall be conducted with motors connected to AFD output and it shall test all inputs, outputs and program execution specific to this application.

Manufactured Units

- a) Pumps shall be installed as per manufacturer specification if any.
- b) The control system shall include as, a minimum, the programmable logic pump controller, adjustable frequency drive(s) and wireless sensor / Sensorless system as required. Additional items shall be included as specified or as required to properly execute the sequence of operation.
- c) The variable speed pump logic controller, adjustable frequency drives, and remote sensor/transmitters/ sensorless controller shall be shipped as individual components to the job site.
- d) Pump logic controller, adjustable frequency drives, sensor/ transmitters and related equipment shall be installed by the mechanical EPC CONTRACTOR as shown on the drawings.
- e) Power wiring shall be done by the EPC CONTRACTOR as shown on the field connection drawings and wiring diagrams supplied with the pumping package.
- f) Low voltage wiring shall be done by the EPC CONTRACTOR as shown on the field connection drawings and wiring diagrams supplied with the pumping package.

10.1 Pump Logic Controller for Secondary Variable Circuit with VFD

- a) The pump logic controller shall be capable of controlling:
Secondary Circuit of Primary Constant & Secondary variable pumping system
- b) The pump logic controller assembly shall be listed by and bear the label of IS/CE/Underwriter's Laboratory INC. (UL). The controller shall meet Part 15

of FCC regulations pertaining to class A computing devices. The controller shall be specifically designed for variable speed pumping applications.

- c) The controller shall function to a proven program that safeguards against hydraulic conditions including:
 - i. Pump flow surges
 - ii. Hunting
 - iii. End of curve
 - iv. System over pressure.
 - v. Motor overload
 - vi. Efficiency based staging
- d) The pump logic controller shall be capable of receiving up to multiple discrete analog inputs from zone sensor / transmitter. It will then select the analogue signal that has deviated the greatest amount from its set point. This selected signal shall be used as the command feedback input for a hydraulic stabilization function to minimize hunting. Each input signal shall be capable of maintaining a different set point value. Controller shall be capable of controlling upto three pumps in parallel.
- e) All sensors / transmitter inputs shall be individually wired to the pumps logic controller for continuous scan and comparison function. Necessary signal boosters shall be indicated in case of long length of cabling. All analog inputs shall be provided with current limit circuitry to provide short circuit protection and safeguard against incorrect wiring of sensors.
- f) The pump logic controller shall have an additional analog input for a flow sensor. This input shall serve as the criteria for the end of curve protection algorithm.
- g) The hydraulic stabilization program shall utilize a proportional-integral-derivative control function. The proportional, integral and derivative values shall be user adjustable over an infinite range.
- h) The pump logic controller shall be self-prompting. All messages shall be displayed in plain English. The operator interface shall have the following features:
 - i. Multi-fault memory and recall last 10 faults and related operational data
 - ii. Red fault light, Yellow warning light and Green power ON light.
 - iii. Keypad switches.
- i) The display shall show information indicating pump status.
- j) Controller shall be capable performing the following pressure booster function:
 - Low suction pressure cut-out to protect the pumps against operating with insufficient suction pressure.

- High system pressure cut-out to protect the piping system against high pressure conditions.
- The following communication features shall be provided to BAS:

- Remote system start / stop non-powered digital input.
- Failure of any system component. Output closes to indicate alarm condition.
- One 4-20 mA output with selectable output of:
 - Frequency
 - Process Variable
 - Output Current
 - Output power.

The following communication features shall be provided to the building automation system via an RS-485 Modbus / BacNET I/P / Ethernet / Metasys

N2 port utilizing internationally accepted open protocol.

- Individual Analog Input
- Individual Zone Set Points.
- Individual Pump / VFD / VSD on/off status.
- System percent speed.
- System Start / Stop command
- System operation mode.
- Individual KW signals.
- System flow.
- The pump logic controller shall be housed in suitable enclosure

10.2 Sensor/ Transmitters

Provide field mounted differential pressure sensor transmitters as per system requirement. Unit shall transmit an isolated 4-20mA dc signal indicative of process variable to the pump logic controller via standard two wire 24 DC system. Unit shall have a corrosion resistant steel body with 1/8" NPT process connection. It shall have a minimum IP54 electrical enclosure capable of withstanding 450 PSI static pressure. Accuracy shall be within 0.5% of full span.

10.3 Sequence of Operation for Secondary Variable Circuit

- a) The system shall consist of a pump logic controller, multiple pump / VFD sets, with manual and automatic alternation and pump staging.
- b) The pumping system shall start upon the closure of customer's contact when the pump logic controller Mode of Operation selector switch is in the REMOTE position.

- c) When the pump logic controller selector switch is in the LOCAL position, and start command is given via operator interface, the pumping system shall operate automatically.
- d) Sensor/ transmitters shall be provided as per design.
- e) Each sensor/ transmitter shall send a 4-20 mA signal to the pump logic controller, indicative of process variable condition.
- f) The pump logic controller shall compare each signal to the independent, engineer/ user determined set points.
- g) When all set points are satisfied by the process variable, the pump speed shall remain Constant at the optimum energy consumption level.
- h) The pump logic controller shall continuously scan and compare each process variable to its individual set point and control to the least satisfied zone.
- i) If the set point cannot be satisfied by the designated lead pump, the pump logic controller shall initiate a timed sequence of operation to stage a lag pump.
- j) The lag pump shall accelerate resulting in the lead pump(s) decelerating until they equalize in speed.
- k) Further change in process variable shall cause the pumps to change speed together.
- l) When the set point criteria can be safely satisfied with fewer pumps, the pump logic controller shall initiate a timed de-stage sequence and continue variable speed operation.
- m) As the worst case zone deviates from set point, the pump logic controller shall
send the appropriate analog signal to the VFD to speed up or slow down the pump/ motor.
- n) In the event of a VFD fault, the pump logic controller automatically initiates a timed sequence of events to start the redundant pump / VFD set in the variable speed mode. The redundant variable speed system shall be started through the pump logic controller.
- o) Upon VFD fault(s), the pump controller shall display an alarm condition through a plain English message.
- p) VFD fault indication shall be continuously displayed on the operator interface of the pump until the fault has been corrected and the controller has been manually reset.
- q) In the event of the failure of a zone sensor/ transmitter, its process variable signal shall be removed from the scan/ compare program. Alternative zone sensor/ transmitters, if available, shall remain in the scan/ compare program for control.
- r) Upon sensor failure a plain English warning message shall be displayed on the operator interface of the pump logic controller.
- s) In the event of failure to receive all zone process variable signals, a user electable number of VFDs shall maintain a user adjustable speed, reset shall be automatic upon correction of the zone failure.

DATA SHEET - A**CHECKLIST AND PERFORMANCE TEST DATA TO BE PROVIDED AFTER
INSTALLATION**

S. No.	Description	Unit	Time			Date			Remarks
			10.00	12.00	14.00	16.00	18.00	20.00	
1.	Suction pressure	Kg/c m ²							
2.	Discharge pressure	Kg/c m ²							
3.	Water flow rate	LPS							
4.	Current	Amps							
5.	Bed plate levels and alignment checks								
6.	Hydraulic test for casing at 1.25 times design pressure								
7.	Noise level from pump	1.8 m dB							
8.	Discharge Vs head	Mtr							
9.	Discharge Vs efficiency								
10.	Discharge Vs BkW								

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6.6 COOLING TOWER (FRP Construction)

1. **SCOPE:**

The scope of this section comprises the supply, erection, testing and commissioning of cooling towers conforming to these specifications and in accordance with system and design requirements.

5 farheinight/ as parameter defined in DBR approach shall be consider for cooling tower.

2. **TYPE:**

Cooling tower shall be Induced draft in accordance with requirement. Cooling towers shall meet the following.

- Cooling Tower shall be CTI certified for thermal performance and shall carry relevant certification label.
- Sound performance shall be in accordance with CTI ATC-128.
- Heat rejection Performance shall be in accordance with ASHRAE 90.1- 2013/ As specified in tender specification.
- Seismic design requirements shall be in accordance with relevant provisions of IS Code/ **National Building Code of India-2016** revised till date.
- **Cooling tower shall meet minimum efficiency criteria as per ECBC-2017 for Super ECBC Category.**

DESIGN

- **Range**
The cooling tower shall be designed to cool the requisite quantity of water through 5.56-degree C or as specified in the tender specifications, against the prevailing wet bulb temperature.
- **Wet Bulb Approach**
The cooling tower shall be selected for a wet bulb approach of 3.5-degree C.
- **Outlet Temperature**
The cold water temperature from the cooling tower shall match the entering temperature for which the condenser selection is made.
- **Flow Rate**
The water flow rate through the cooling tower shall match that through the condenser.
- **Cell Design**
The induced draft cooling tower shall be of one or multi cells.

3. **FRP INDUCED DRAFT COOLING TOWERS:**

Fibre reinforced plastic cooling towers shall be with one or multicells as per OEM best selection. Tower shall be vertical, induced draft, counter flow type, fibre reinforced plastic construction, in rectangular shape, square or bottle shape, complete with fan, motor, surface and spray sections, G.I ladder eliminators, automatic controls and sound attenuation equipment as per system and design requirements. One isolating switch of appropriate rating conforming to IP55 shall be provided near the cooling tower for maintenance purpose.

3.1 Capacity:

The cooling tower capacities shall be as per the approved design calculation, approved shop drawing submit to EPC Contractor.

3.2 Side Casing:

The casing shall be made out of FRP/GRP construction of suitable thickness and UV retardant fibre glass reinforced polyester stabilized with finished surface outside and smooth surface in side for minimum resistance to air flow. It shall have sufficient structural strength to adequately withstand high wind pressure on any external surface and vibration as per CTI standard.

The casing may be installed in the reinforced cement concrete basin as per design. The cooling tower shall not be less than 75 cm above the ground / floor level. The tower supporting structure shall be made out of hot dipped galvanized tubular frame. Air intake shall be all along the sides so that tower can be installed quite independent of prevailing wind direction. Anodized aluminum or PVC louvers integrated with fill and backed up by galvanized bird screen shall be provided at air intake. Sufficient clearance between casing and adjoining structures shall be provided to enable servicing and periodic cleaning. The fan guard shall be as per standard and designed to prevent contact between fan and human finger.

3.3 Cold Water Basin:

Cold water basin shall be a deep sump of FRP on which cooling tower super structure shall be supported as per design.

Basin fittings shall include the following:

- i. Bottom outlet.
- ii. Suction screen assembly.
- iii. Drain connected to the side / underside of basin with valve.
- iv. Overflow connected to the side of basin.
- v. Built in bleed off attached to inlet header & discharging through polyethylene tube into overflow pipe.
- vi. Ball type automatic make up water valve.
- vii. Quick fill connected to the side of basin.
- viii. Equalizing connection and balancing valve for multiple Cooling Towers

The cooling tower shall not be less than 75 cm above ground / floor level.

The treated water of hardness as ppm of CaCo3 is reduced to 50 ppm or below, is recommended for air-conditioning applications.

3.4 Distribution System:

Hot water distribution system shall comprise of header and branch arms system with flow balancing system or open pan gravity flow system. No overflow or splash of water shall be allowed at design flow rates.

3.5 Filling:

Fillings shall be made of corrosion proof and rigid PVC film in honey comb design and arranged in square / rectangular form. Thickness of PVC fills shall not be less than 0.2mm. Fill sheets shall be suspended from H.D.G steel structural tubing supported from the lower structure & shall be elevated above the floor of the cold water basin to facilitate cleaning and easy replacement. They shall be arranged in such a manner to ensure negligible resistance to air flow and to eliminate back water spots and prevent fouling through scales that may form. In order to reduce carry-over losses through entrainment of moisture drops in air stream, PVC drift eliminator shall be installed.

3.6 Drift Eliminator

In order to reduce carry-over losses through entrainment of moisture drops in air stream, UPVC drift eliminator shall be installed to limit drift losses of the total water circulated.

3.7 Mechanical Equipments

The tower shall be provided with low speed fan Direct driven or gear driven mounted fan to achieve sound noise level specified. Fan shall be of the propeller type, cast aluminium, low weight rotor fitted with multiple aerofoil blades (FRP/GRP/Aluminium Material). The entire fan assembly shall be statically and dynamically balanced. Fan shall be directly driven/ gear driven by a $415 \pm 10\%$ volts, 3 phase, 50 cycles AC supply electric motor (minimum IE-4). The fan motor shall be suitable for VFD operation.

Fan motor shall be of totally enclosed, fan cooled weather proof construction (**IP-55**), designed and selected to operate IP55 protection in humid air stream. Fan shall be protected by fan guard & shall be easily accessible for inspection and maintenance. A galvanized service ladder shall also be provided for maintenance.

The mechanical equipment assembly shall be adequately supported on a rugged steel base welded to tubular support assuring vibration-free support.

Fan guard and bird screen (of galvanized steel construction) shall be provided to prevent birds from nesting during idling periods. Gear-reducer shall be –of spiral bevel type.

G.S.S canopy shall be provided over the fan motor for protection against rain water. Care shall be taken that fan air is not restricted. Motor terminal box shall be made water tight.

4. PAINTING:

The exterior steel surfaces of all towers shall be given two coats of paint of approved finish. If these shop coats become marred during shipment or erection, the affected areas shall be cleaned off with mineral spirits, wire brushed and spot primed then coated with enamel paints of matching shades. FRP towers shall be provided of color approved by Architect/client.

5. NOISE LEVELS:

The noise level from cooling tower shall around 75 dbA from 3 meter distance all around the cooling towers

6. PERFORMANCE SUBMITTALS

- Manufacturer shall submit certificate from CTI validating capacity of cooling tower at tender design conditions (entering and leaving condenser water temperature, entering air wet bulb temperature, water flow rate, fan kW).
- In addition, manufacturer shall also provide certificate that the cooling tower, accessories and components withstand the seismic force as per zone defined by **National Building Code-2016 of India, revised upto date.**
- Sound level along with sound curves and characteristics of sound attenuators, if required to meet the noise criteria.
- Manufacturer shall submit complete performance rating and power consumption at varying loads & varying outdoor wet bulb temperatures. The same shall be verified at the time of testing and commissioning of the installation.

7. TESTING AT SITE

Capacity of the cooling tower shall be computed from the measurements of the water flow, incoming/ outgoing water temperatures and ambient air wet bulb temperature using accurately calibrated mercury –in-glass thermometers. Computed ratings shall conform to the specified capacities and quoted ratings. Power consumptions for cooling towers shall be computed from measurements of incoming voltage and input current.

8. INSTALLATION

The cooling tower shall be installed on M.S. girders fixed in masonry foundations with cement concrete footing.

These may be located at a well-ventilated place either at ground level and contiguous to the plant room, or on the terrace of the building in consultation with the Architect. In case the cooling towers are located on the terrace of the building, the structural loading of the terrace shall be considered. For this respective columns are to be raised by two feet at the terrace. Cooling towers shall be installed in such a way that their load is transferred directly to the columns for which necessary Mild steel-I sections shall be provided by the airconditioning contractor. The cooling towers shall be rested on Mild Steel-I sections & not on terrace slab. Sufficient free space shall be left all around for efficient operation of the cooling tower.

Cooling tower shall be not less than 75cm above the ground/ floor level unless otherwise stated in the tender specifications. 6mm neoprene pads shall be placed between the tower and the girder for vibration isolation whereas directed by the Engineer-in-charge.

6.7 INTELLIGENT ANTI FOULING CONDENSER SYSTEM/SMART AUTOMATIC TUBE CLEANING SYSTEM

Control Panel:

The Control Panel system shall include IoT Ready, Industry 4.0 complaint device. The Panel should have minimum 7" Touch Screen Graphical HMI which will log the real time data related to chiller energy (KWH), capacity (TR), Chiller Water Flow monitoring, Water Temperature profile on evaporator and condenser both, compliances and graphical representation of historic summary which shall be displayed on the Mobile Application with unlimited user access on cloud based system. The data can also be retrieved in XL or PDF Format. The HMI should have depiction of injection and collection cycle. The alarms and faults shall be indicated on the screen in case of any issue in operation. Display must be Touch type, graphical presentation, and with multi-level security passwords with defined functional authorities. Field Devices like Energy Meter, Flow Meter, Temp. Sensors shall be picked up from BMS/CPO Scope of Supply & Data shall be replicated from skid via Modbus protocol.

Ball Trap:

The ball trap shall be mounted between two flanges - (BS Table 10 E) Grade B, 15 days 100 lbs capacity, at the outlet line of the condenser. The casing shall be made from a MS material of IS2062 Grade B. The Ball trap shall have epoxy based finished paint. The screen inside is made from stainless steel SS304L perforated metal sheet.

The Ball Trap should have pressure drop of less than 800 mm of WC. The body of the Ball trap shall be of size as nozzle or flange size or the pipeline size in which Ball trap must be installed. For example: if the pipeline size is 10 inches the Ball trap body should be of 10 inches.

The Ball Trap shall have Race Face Flange with gasket on only inner dial of pipe and should not be on the entire flange dia to avoid leakage.

Ball Collector:

The ball Collector shall be made of suitable size capable of storing all the sponge balls required and should be made from MS material of IS2062 Grade B. The Ball collector should have epoxy based finished paint. The Ball Collector should have a sight glass for monitoring the balls. Toughened glass should be used and should be mounted by Allen key fasteners or SS nut bolt.

Skid with Pumps & Valves:

The Common Skid should have pipe and flanges of MS material IS2062 Grade B. All welding of Skid shall be performed by Argon weld. The Skid frame should be of MS material of same IS2062 grade B. The Skid valves should be of diaphragm type or equivalent with all joints to be flanged and bolted. The valves used for injection and collection from respective chillers shall be of actuator type with minimum IP54 protection and less than 10s running time for open or close

function with NEMA –II protection. The valve should be suitable to work in high humid environment up to 95% (Non-condensing) RH. All fasteners shall be of high-tension grade 9.8, 10.9, 12.9. Pumps shall be from reputed makes like Grundfos/Xylem/Amstrong. Motorized Valves shall be from reputed makes like Belimo/Danfoss/Siemens/JCI.

Working Principle - Activity Sequence:

The operation is based on the circulation of the sponge ball through the condenser tube. The sponge ball must be pushed to the condenser inlet in not more than 5 seconds by a high flow of water (min. 7L/S) which can be produced by a high-pressure source at least 2bar higher than the injection point at the condenser inlet. The source can be obtained by a single water injection pump in water injection system. Water injection system will be operated by a PLC controller which is pre-programmed to execute the cleaning process in two consecutive steps. There shall be ball injection cycle and ball collection cycle. The proposed system should be manufactured and complied with ISO 14001:2015, ISO 9001:2015. The system must be CE + RoHS compliant and in accordance with UL standards.

STEP 1:

The PLC shall activate the cleaning process by detecting the on/off status of the corresponding chiller (or condensing water isolating valve). If the chiller is on, the PLC shall command the control valves to open to manage the injection. The check valves shall be installed in the location as shown on the scheme above and as close as possible to the collector to ensure correct water flow direction during the injection cycle and the collection cycle.

STEP 2:

The injection cycle, the PLC shall command the injection control valve to open for couple of seconds (the collection control valve kept closed in the cycle) and then close. The water pressure from the pump shall be used to push the water inside the injector to the collector and force all balls in the collector to the condenser.

STEP 3:

The cycle shall be completed until the ball passing through the condenser where it should clean all the deposits on internal surface of the tubes. After leaving condenser the balls shall be trapped inside the ball trap unit.

STEP 4:

After the injection cycle is finished, the PLC shall command the collection control valve to open for couple of seconds (the injection control valve kept closed in the cycle) and then close. The negative pressure shall let the ball return from the ball trap unit back to the collector where the rinsing of the balls is carried out and then water is discharged to the outlet header of Condenser which goes to

cooling tower. The ball shall wait in the collector until the next injection cycle. The time of the collection cycle is normally pre-set at 27 minutes.

1. A single pump should be on skid and shall be running during injection and collection cycles.
2. The pressure drop across ball trap shall not be more than 800mm.
3. The Valves shall give feedback to Control PLC of functioning.
4. The Control PLC shall raise an alarm in case of any malfunctioning of system
5. The total time of the whole cycle (injection and collection cycle) shall be 3 - 4 minutes.
6. A maximum number of 4 Condensers should be controlled by single skid and Control Panel. If the number of Condenser increases beyond 4, additional Skid with Control Panel should be considered and should be followed consequently.

BBB X DDD

6.8 ELECTRO-CHEMICAL TREATMENT SYSTEM

System Description: Electro-chemical treatment system for cooling tower works in side stream without disturbing Cooling Tower Operations. The system should deploy an electrolysis reaction with controlled constant DC current which creates Electrolysis Reaction generating (-OH) Ions at Cathode which creates high PH on the walls of cathode, this results in precipitation of calcium and magnesium salts present in the water into the electrolytic reactor and Chlorine gas is generated at anode which acts like Biocide and avoids bacterial growth and algae formation. The system should be equipped with Automatic Self Cleaning Mechanism & Automatic Blowdown Control. The proposed system should be manufactured and complied with ISO 14001:2015, ISO 9001:2015. The system must be CE + RoHS compliant and in accordance with UL standards. The proposed system should minimize blow down water consumption up to 70%. No/Zero Chemicals uses for cooling tower circuit, technology must fall under green technology initiatives, the system must avoids algae and micro-bacterial formation in water or surface of Pipe/ CT/ fills. Self-treatment of Corrosion in the cooling water circuit, must extends life of the Cooling Tower Fills. The system must have below components:

1. **Electrolytic Reactor:** An electrolytic cell has three components parts: an electrolyte and two electrodes (a cathode and an anode). The electrolyte is usually a solution of water or other solvents in which ions are dissolved. Molten salts such as sodium chloride are also electrolytes. When driven by an external voltage applied to the electrodes, the ions in the electrolyte are attracted to an electrode with the opposite charge, where charge-transferring (also called faradaic or redox) reactions can take place.
2. **Automated Scrapper mechanism for reactor cleaning:** The Reactors need frequent cleaning and the system must be equipped with self-cleaning reactors to ensure zero down time and manual interventions.
3. **Automatic Blowdown control:** Automatic Blow Down feature allows only the required quantity blow down based on the real time monitoring of Chlorine, PH and conductivity. This feature in system ensures the drain valve operation and need no manual interventions.
4. **Side screen Filter:** The Side Screen filter is provided in side stream water coming out thru electrolyte process. This filter eliminates any particle in water to travel across. The possibility of scraped debris and substance are being avoided with the feature.
5. **Automatic Back wash:** Automatic Back wash is a feature of Side screen filter in which the filters are being cleaned automatically with the feedback of pressure drop. The motorized valves are provided to reverse the direction of

water and the cleaning of side screen filter being taken care automatically.

6. **Control Panel:** This makes system Industrial 4.0 compliant and to be future ready (Optional Feature). The panel is monitoring status of individual cooling tower and modulating the water flow control valves. The real time monitoring of PH, TDS and Conductivity happen and any common to modulate DC current/ Voltage/Drain/Back Wash/Scrapping and self-cleaning is initiated automatically. The panel will have 7" inches touch display with graphical representation.
7. **Skid with Pumps & Valves:** The Common Skid should have pipe and flanges of MS material IS2062 Grade B. All welding of Skid shall be performed by Argon/ARC weld. The Skid frame should be of MS material of same IS2062 grade B. The Skid valves should be of diaphragm type or equivalent with all joints to be flanged and bolted. The valves used for injection and collection from respective chillers shall be of actuator type with minimum IP54 protection and less than 10s running time for open or close function with NEMA –II protection. The valve should be suitable to work in high humid environment up to 95% (Non-condensing) RH. All fasteners shall be of high-tension grade 9.8, 10.9, 12.9. Pumps shall be from reputed makes like Grundfos/Xylem/Amstrong. Motorized Valves shall be from reputed makes like Belimo/Siemens/Honeywell/JCI.

Scope of Supply:

The scope of supply would be as given below:

1. Self-Cleaning Reactor with Anode and Cathode
2. Control Panel with PLC & Multicolor HMI
3. Circulation Pump
4. PH, TDS, Conductivity Meter for real time monitoring
5. Side Screen Filter with Pressure differential monitoring
6. Automatic Back wash & Blow-down Arrangement
7. Self-Scrapping mechanism
8. Motorized Valve
9. Manual Valves
10. Flow Switch and Pressure Gauge
11. Skid & Accessories

6.9 DOUBLE SKIN AIR HANDLING UNITS

1. SCOPE

The scope of this section, comprises the supply, erection, testing and commissioning of double skin construction air handling units, conforming to these Specifications and in accordance with requirements.

2. TYPE

The air handling units shall be double skin construction, draw through/ blow through type comprising of various sections, pre filters (MERV-8). EAC filter section, coil section and fan section, mixing box with volume control dampers, (wherever the return air and fresh air are ducted) as per approved shop drawings.

3. CAPACITY

The Air handling capacities, static pressure shall be as per design requirement and calculation.

4. CASING

Double skinned panels shall be 40 mm thick made of galvanized steel, pressure injected with PUF insulation (density 38 kg/cum) between both inner and outer skin shall be fixed to 1.5 mm thick aluminum alloy twin box section structural framework with stainless steel screws. Outer sheet of panels shall be made of galvanized pre-coated sheet of minimum 0.8mm and inner sheet of 0.8 mm plain G.I. Sheet.

The entire framework shall be mounted on an aluminum alloy or galvanized steel (depending on size) channel base as per manufacturer's recommendation. The panels shall be sealed to the framework by heavy duty 'O' ring gaskets held captive in the framed extrusion. All panels shall be detachable or hinged. Hinges shall be made of die cast aluminum with stainless steel pivots, handles shall be made of hard nylon and be operational from both inside and outside of the unit. Units supplied with various sections shall be suitable for onsite assembly with continuous foam gasket. All fixing and gaskets shall be concealed.

Units shall have hinged, quick opening access door in the fan section and also in filter section where filters are not accessible from outside. Access doors shall be double skin type.

Condensate drain pan shall be fabricated from 1.25 mm thick stainless steel sheet externally insulated with 10mm thick closed cell polyethylene foam insulation or nitrile rubber or PUF with necessary dual slope to facilitate fast removal of condensate. Necessary supports will be provided to slide the coil in the drain pan with all corners welded. It shall be isolated from bottom floor panel through 25mm heavy duty TF expanded polystyrene or urethane foam.

AHU panels shall be factory fitted with pressure ports for DPT installation. The number and size of these shall be confirmed in the AHU technical approval stage. In case opening is to be made in AHU panel, the same shall be with C-channel all around to prevent entry of PUF into air stream. The channels shall be cut at 45 degrees at the corners to avoid overlap. Material for the channel shall be same as that of internal skin of AHU.

Rubber grommets shall be provided at all entry points into AHU such as coil connection, cable entry etc. The same shall be double lip tight fitting to prevent air leakage.

All access doors shall be outward opening. For doors provided downstream of the fan, especially in high static AHUs, additional clamps shall be provided along periphery of door to maintain constant pressure and ensure proper sealing.

Water resistance marine light with power cabling shall be included.

Micro switch with wiring for Door shall be provided such that fan motor shall stop upon opening the door.

5. THERMAL BREAK PROFILE

All AHUs shall be provided with thermal break profile. Panels and thermal break profiles for all AHUs shall be designed and assembled in such a way that there shall not be any condensation on AHU with conditions of 35°C and 92% RH (AHU surrounding conditions) at designed operating conditions inside the AHU.

6. DAMPER

Dampers shall be opposed blade type. Blades shall be made of double skinned airfoil aluminium sections with integral gasket and assembled within a rigid extruded aluminium alloy frame. All linkages and supporting spindles shall be made of aluminium or nylon, turning in teflon bushes. Manual dampers shall be provided with a bakelite knob for locking the damper blades in position. Linkages shall be extended wherever specified for motorised operation. Damper frames shall be sectionalized to minimise blade warping. Air leakage through dampers when in the closed position shall not exceed 1.5% of the maximum design air volume flow rate at the maximum design air total pressure.

7. MIXING BOX

AHU's requiring mixing boxes as per duct design which shall be complete with fresh and return air dampers.

8. MOTOR AND DRIVE FAN

AHU shall be provided with direct drive plug fan with EC (Electronically Commutated) permanent magnet brushless DC motor for stepless variation of speed of fan (motor efficiency should not less than IE-4 rating). Motor shall be suitable for modulation based on 0-10 Volts signal, which can be given through temperature/ duct pressure sensors. A potentiometer for manually speed control of EC fans shall be provided. AHU shall have control box/electrical

terminal box (complete with MPCB/MCCB/ MCB/starter) with Auto-Manual switch and incomer power terminal, with SPP, over/ under voltage protection, short-circuit protection and with NO-NC contacts (potential free contact) to be provided for tripping on signal from Fire Dampers / Fire Alarm Panel. Power cable from Terminal box to motor & control cabling of required size upto the thermostat - sensor etc. to be provided. Temperature sensor to be placed in return air duct for EC motor modulation. Potentiometer, 24 V Transformer for temperature sensors with thermostat, Auto / Manual switch, potential free contact, temp sensor, control panel, along with internal cabling.

9. COOLING COILS & HEATING COIL (AHRI certified)

Chilled water coils shall have 12.5 mm to 15 mm dia (O.D) tubes minimum 26 SWG (0.5mm) thick with sine wave aluminium fins firmly bonded to copper tubes assembled in stainless steel frame. Face and surface areas shall be such as to ensure rated capacity from each unit and such that the air velocity across the coil shall not exceed 155 meters per minute. The coil shall be pitched in the unit casing for proper drainage. The coil shall have copper header with chilled water supply & return connections protruding out of AHU casing by minimum 150 mm and fitted with dielectric coupling or adapter for connection with MS pipes. Each coil shall be factory-tested at 21 kg per sq. cm air pressure under water for one hour. Water coils shall be designed for a maximum working pressure of 10 kg/sq.cm. Tube shall be hydraulically/ mechanically expanded for minimum thermal contact resistance with fins. Fin spacing shall be 11 to 13 fins per inch (4-5 fins per cm). Water pressure drop in coil shall not exceed 10 PSIG(0.70 kg/cm.sq.). For coastal areas fins shall be phenolic coated and 100% F.A. application fins shall be hydrophilic type.

Coils shall be provided with mechanical means to purge air from the coil during commissioning by means of a purge valve or nipple. To prevent splashing, discharge from the same shall be routed to the condensate drain pan by means of flexible PVC tubing of suitable diameter.

Purge valve / nipple shall be accessible externally or by removal of blanking panel. All AHU's shall be provided with minimum 6 Row deep Cooling / heating Coil.

In case AHU has multiple coil stacked one above another, intermediate drain tray of SS 304 (18 gauge) shall be provided so that upper level of coil drains into this drain tray. SS 304 piping shall be provided from this drain tray upto main bottom tray.

Computerized cooling coil selection output shall be submitted. Coil rating shall be as per AHRI-410.

10. FILTER SECTION (For all AHUs/ TFA/ HRW, refer filter section head of TS):-

11. ISOLATORS

Vibration isolators shall be provided with all air handling units. Vibration isolators shall be cushy foot mounting type. Minimum vibration isolation

efficiency shall be 90% and certificate of vibration isolator shall be provided by Contractor.

12. ACCESSORIES

Each air handling unit shall be provided with manual air vent at high point in the cooling coil and drain plug in the bottom of the coil. In addition, the following accessories may be required at air handling units, their detailed specifications are given in individual sections.

12.1 Insulated butterfly valves, balancing valves/PID/PIBCV Valve with thermostat, 'Y' strainer, union & condensate drain piping with 'U' trap upto sump or floor draining in air handling unit room, as described in section "Piping".

12.2 Thermometers in the thermometer wells & pressure gauge (with cocks) within gauge ports in chilled supply and return lines as per the section "Instruments".

12.3 Minimum 2 Nos nameplates (1 in etched metal and other plastic) mounted onto AHU panel with suitable water resistant adhesive along with relevant warning stickers on various panels. The nameplate shall give all relevant details including fan model selected, motor KW, Air quantity and total static pressure.

13. PAINTING

Shop coats of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with paint to match the finish over the adjoining shop painted surface.

14. NOISE CONTROL

Air Handling Units shall be selected for the lowest operating noise level of the equipment. Fan performance rating, power consumption, and sound power data with operating points clearly indicated shall be submitted by the tenders along with technical submittals for approval and verified at the time of testing and commissioning of the installation. The sound level within the AHU room shall be less than **75 dB** at a distance of 1 meter from AHU.

15. CONNECTIONS

Piping installation requirements are specified in other section. The Drawings indicate the general arrangement of piping, valves, fittings, and specialties. The following are specific connection requirements:

- Arrange piping installations adjacent to units to allow unit servicing and maintenance.
- Connect piping to air-handling units with flanges enabling easy removal of the coil
- Connect condensate drain pans using 50 mm (2-0 inch) minimum, insulated G.I. pipe and extend to nearest floor drain. Construct deep trap

(depth as per detail) at connection to drain pan and install cleanouts at changes in direction.

- Duct installations and connections are specified in other sections. Make final duct connections with flexible connections.
- Electrical Connections: The following requirements apply:
 - Electrical power wiring is specified in section Electrical.
 - Temperature control wiring and interlock wiring is specified in Section "Electrical
- Control systems."
- Grounding: Connect unit components to ground in accordance with the Indian Electrical Code.

16. ADJUSTING, CLEANING, AND PROTECTING

- Adjust water coil flow, with control valves to full coil flow, to indicate lpm (gpm).
- Adjust damper linkages for proper damper operation.
- Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, and coils entering air face.

17. COMMISSIONING:

- Final checks before start-up Perform the following operations and checks before start-up:
- Remove shipping, blocking and bracing.
- Verify unit is secure on mounting and supporting devices, connections for piping, ductwork and electrical are complete. Verify proper overload protection is installed in motors, starters, and disconnects.
- Perform cleaning and adjusting specified in this Section.
- Lubricate bearings and other moving parts with factory recommended lubricants.
- Set outside-air/ supply air dampers to minimum outside-air setting.
- Comb coil fins for parallel orientation.
- Install temporary throw away filters for initial run and finally install clean filters.
- Verify manual and automatic volume control, and fire dampers in connected ductwork system are in the full-open position.
- Disable automatic temperature control operators.
- Starting procedures for central station air-handling units:

- Energize motor, verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicate RPM.
- Replace fan and motor couplings as required to achieve design conditions.
- Measure and record motor electrical values for voltage and ampere.
- Shut down and reconnect automatic temperature control operators.

18. TESTING

Cooling capacity of various Air handling units shall be computed from the measurements of air flow and dry and wet bulb temperatures of air entering and leaving the coil. Flow measurements shall be by a calibrated rotating vane anemometer and temperature measurements by accurately calibrated mercury-in-glass thermometers. Computed ratings shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current, whereas, noise level at various locations within the conditioned spaces shall be measured by a sound pressure level meter.

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6.10**HEAT RECOVERY VENTILATION SECTION: (ENTHALPY WHEEL)**

- a. Wheel: The wheel shall be made of alternate layer of corrugated and intervening flat composite material of aluminium foil of uniform width to ensure smooth surface. The wheel medium should be bonded together to form rigid transfer medium forming a multitude of narrow channels ensuring laminar flow. The wheels shall be of proven design.

The wheel can be fully wound or on larger units, sectorised, i.e. assembled in segments. In latter case the segments are assembled between rigid spokes thus ensuring structural longevity and allowing replacement of one or specific segments only.

The wheel shall be cleanable by spraying its face surface with compressed air, low temperature steam or hot water or by vacuum cleaning without affecting its latent properties.

The face velocity across the wheel should not exceed 700 fpm (3.5 m/s).

The wheels shall be tested in accordance with ASHRAE S4-78 method of testing air to air heat exchangers. Development and manufacturers shall meet all quality assurance criteria specified in BSEN ISO 9001.

The minimum sensible and latent efficiencies should be 75%. A computerized selection should be enclosed along with offer.

- b. Casing: The casing shall be constructed as a single skin, self-supporting, galvanized sheet steel structure and include rotary wheel support beams and purging sector. The casing shall be supplied with access panels to facilitate inspection and service. Size 2150 mm and larger shall be in two sections to facilitate shipping and handling.

- c. Seals: The casing shall be equipped with adjustable brush seals, which minimize the carryover to max 0.05 – 0.2%.

- d. Hub and Spokes: Hub and Spokes on one piece rotor shall be Aluminium and on sectorized rotor Hub shall be made of steel, painted with anti corrosion paint and galvanized sheet steel spokes.

- e. Drive: The wheel shall be belt driven along its perimeter. A constant speed fractional horsepower motor shall be used. The motor shall be mounted on a self-adjusting base to provide correct belt tension.

TESTING

The Thermal Wheel shall be tested in accordance with the parameters fixed as below.

- Supply Air Capacity - FDB/FWB.
- Exhaust Air Capacity - FDB / FWB.
- Fresh Air Capacity - FDB / FWB

Heat exchanger units(HRV) in double skin construction, constructed out of extruded Aluminium section frame with puf insulated panels, blowers, IE-4 Motor plate to plate type Aluminium heat exchanger and filters. The unit will have two separate passages one for supply of fresh air and the other for exhaust of cool air

from the rooms after the recovery of energy. Efficiency of these heat exchangers shall be 60-65%.The plate to plate heat exchanger shall be rigid thermally bonded seamless Aluminium channels separated by extruded aluminium spacers of the following capacity.

6.11 CASSETTE TYPE CHILLED WATER UNIT

1. SCOPE

The scope of work comprises the supply, installation, testing and commissioning of the cassette and Hi wall chilled water units conforming to these specifications.

2. GENERAL REQUIREMENTS

The chilled water Cassette units shall be ceiling suspended/Concealed type complete with casing, fan, motor, cooling coil made of copper tubes with aluminium fins, filter, built in drain pump and insulated drain pan.

3. DESCRIPTION:

The unit shall be four way Cassette type and will comprise of 3 dimension screw fan, coil section, 3 speed motor, circuit box, cleanable fabric filters , decorative panel, thermostatic controls, drain pump assembly, galvanised sheet steel casing with G.I coated finish .

The drain pump mechanism shall be suited to lift water up to a height of at least 500 mm and shall be interlocked in such a way that in case the drain pump does not function, the unit shall stop functioning and give warning signal. Unit shall be selfdiagnostic type.

4. CONSTRUCTION DETAILS:

4.1 Casing - The unit casing shall be fabricated from 18 Gauge G.I sheets and decorative panel with ABS Plastic. Access panel shall have positive locking fasteners for easy removal.

4.2 Fan – The fan shall be directly driven Centrifugal forward curved statically and dynamically balanced.

4.3 Fan motor – It shall be suitable for 220v +/- 10%, 50 Hz, single phase A.C supply with minimum 3 speeds., Motor shall be energy efficient, six pole with max. speed not exceeding 1000 rpm.

4.4 **Cooling coil** - Coil shall be made up of copper with min.7mm OD and wall thickness of 0.4mm. Coil shall be minimum 2/3 row deep suitable for operation on chilled water and accordingly return headers shall be provided. The coil sizes and capacity shall be adequate for desired refrigeration performance.

The coil fins will be hydrophilic aluminium type for long life of equipment. Minimum fins per inch shall be 12. Coil tubes shall be mechanically/ hydraulically expanded for minimum thermal contact resistance with fins. Air vent shall be provided in headers at a higher level in the coil. All coils shall be factory tested at 21 Kg/ Sq.cm air pressure while submerged in water for one hour. Water coils shall be designed for a maximum working pressure of 10 kg/sq.cm

4.5 Filter – Unit shall be provided with cleanable fabric filter having an efficiency of at least 70% down to 20 microns.

4.6 Drain Pan – Pan shall be self-contained with 15mm thick EPS insulation. The inside of the insulation shall be suitably treated for preventing water absorption. The pan will be of sufficient size to catch all drip page of condensation from any part of the unit.

4.7 The cassette unit shall be provided with cordless remote controller having controlling functions like set temperature, fan speed, change modes and timer on/ off. Alternate provision for wired controller with digital display shall also be provided. Each unit shall have high lift drain pump, fresh air intake provision.

5. INSTALLATION

The chilled water cassette units shall be hung from the ceiling using anchor fasteners for robust fitting. The unit shall be hung using minimum 12 mm dia threaded rods with minimum height of 15 inches for level adjustment. The hanging accessories will be galvanised.

An auxiliary drain tray arrangement shall be provided to house ball valves, strainer, on/off control valve assembly. Water from this auxiliary tray arrangement shall go back into the main drain tray and no additional drain pipe outlet shall be provided. A factory built valve station comprising of ball valve with strainer at inlet and ball valve without strainer at outlet with PIBCV valve at the outlet shall be provided along with the cassette units.

6. CONTROLS

6.1 The controls for cassette units shall consist of combined thermostat with speed switch and PIBCV valve. The valve shall be suitable for 220V, 50 Hz operation. Brass ball valves with or without strainer provided at inlet and outlet connections.

7. PERFORMANCE

Cassette unit shall be rated for cooling as per AHRI 440- 2008. Unit shall be able to deliver air @400cfm/TR at the highest speed.

8. NOISE LEVEL

The noise level of the unit will not exceed 45 db (A) at a distance of 1m from the unit at high speed.

9. TESTING

Cooling capacity of various unit models shall be computed from the measurements of air flow and dry and wet bulb temperatures of air entering and leaving the coil. Flow measurements shall be by anemometer and temperature measurements by accurately calibrated mercury in glass thermometers. Computed ratings shall confirm to the specified capacities and quoted ratings. Power consumption shall be computed from the measurements of incoming voltage and input current.

6.12 FAN COIL UNIT

1. Scope:

The scope of work comprises the supply, installation, testing and commissioning of the fan coil units conforming to these specifications.

2. Fan Coil Units (Ceiling mounted) :

The fan coil units shall be finished type, ceiling mounting type complete with finned coil, blower with motor, drain pan, air filters, 2 way snap acting valve /PID valve along with snap acting thermostat and actuator with all control wiring etc. and encased in a decorative casing of M.S. powder coated with aluminium supply & return air grills. The casing shall be fabricated out of minimum 1.0mm thick G.S.S. sheet.

3. Cooling Coil/Heating Coil

The coil shall be of seamless copper tubes not less than 9 mm O.D. 0.36 mm thick (Minimum), coil shall have continuous aluminium plate fins and shall have minimum 3 rows. The fins shall be spaced by forming integral part of the fins. The tubes shall be staggered in the direction of air flow. The coil circuit should be sized for adequate water velocity but not exceeding 1.8 M/S (6 F.P.S.) the fins shall be bonded to the tubes by hydraulic expansion of the tubes. The coil shall be of seamless copper tubes with aluminum fins. The fins shall be uniformly bonded to the tubes by mechanical expansion of the tubes. The air velocity across the coil shall not exceed 155 m/min.

The coils shall be tested against leaks at a hydraulic pressure of 10 kg/sq. cm. This pressure shall be maintained for a period of 2 hours. No. drop should be observed indicating any leaks.

4. Fan

This shall consist of (2) two lightweight aluminium impellers of forward curved type, both statically and dynamically balanced, along with properly designed G.I. sheet casing. The two impeller shall be directly mounted on to a double shaft, single phase, multiple winding motor capable of running at (3) three speed. A G.I. plenum shall connect the fan out let to the coil.

5. Drain Pan

The drain pan shall be of 1.25 mm G.I. sheet covering the whole of coil section and extended on one side for accommodating coil connection etc. and complete with a 25 mm drain connection. The drain pan shall be insulated with 12 mm polyethylene insulation.

6. Air Filter

The filter shall be cleanable type 15 mm thick with 90% efficiency down to 10 micron of dry cleanable synthetic type to be mounted behind the return air grill In the Unit casing.

7. Water Connections :

The water valves on inlet line shall be of gun metal ball type with integral water strainers, having BASP (FPT) inlet and flare type MPT outlet connection. The valves on return line shall be as above, but without the water strainer.

The water lines shall be finally connected to the coil of the fan coil unit, by at least 300 mm long, type L seamless solid drawn copper tubing with flare fittings connections. The same shall also be insulated with 15 mm tubular insulation.

8. Controls :

Each unit shall have corded remote for ON/OFF, temperature setting, speed control. It shall also have 24 hour programmable time, louvers & sweep mode, sleep mode and dry mode. Each unit shall have a room type thermostat and a PICB valve. The valve shall be fixed at a convenient location. The thermostat shall be mounted along with the speed control switch on a common plate. The plate shall clearly indicate the fan positions. The water valves on inlet line shall be of gun metal ball type with internal water strainers, having SSP female pipe thread inlet and flare type male pipe thread outlet connection. The valves on return line shall be as above, but without the water strainer.

A sturdy switch shall be provided with the unit complete with wiring, for ON/OFF operation and with minimum three speed control of the fan. Unit shall be enclosed in M.S. powder coated with Aluminium grills for supply and return air and all controls, valves etc.

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6.13 PRECISION AIR CONDITIONING

1. SCOPE

The scope of work comprises of supply; installation, testing and commissioning of self-contained direct expansion type High Sensible Precision air conditioning units with Heater or Humidifier suitable for operation on R410A refrigerant and should have advanced microprocessor to the below specifications.

2. General

Modular construction Precision air conditioning unit suitable for operation on R410A refrigerant with Top/ bottom discharge arrangement consisting of inlet filter, Draw through direct drive Electronically commutated Motor and Backward curved Plug fans, fan motor assembly to deliver desired air quantity, Scroll Compressor, Direct Expansion Cooling Coil, condensate drain pan of Stainless Steel construction, Microprocessor panel, programmable control complete with LCD display. The unit should be suitable for operation on 415 V, 50 Hz, AC supply.

3. Unit Base & Casing

Base panel shall be constructed out of sandwich panels of galvanized steel and painted with epoxy powder. All four side panels (including front door) shall be double skinned sandwiched panels. The panels shall be insulated on the inside with minimum 30 Kg/ cum glass wool, for fire insulation class A1. Unit shall be complete with space for refrigeration equipment, fans, cooling coils, liquid receiver and multistage strip heaters and modulating Humidifiers. Unit shall be provided with welded tubular steel floor stand with adjustable legs and requisite vibration isolation pads.

4. Fan

The units should be equipped with direct driven backward curved EC radial fans with electronically commutated brushless motors; the technology employed by these motors allows straightforward control of fan speed by means of the electronic controller in order to obtain step less adjustment of air flow rate and static pressure to ensure correct distribution of the treated air. The motor's high efficiency should make for less energy absorption, especially at partial loads and during starting (lowering of peak current), which means a reduction in power consumption of approximately 30% compared to AC motor. The motor shall have minimum IP54 Protection.

5. Filters

The filter chamber shall be an integral part of the system and withdraw able from the front of the unit. Filtration shall be provided by deep V form G4 performance dry disposable media to AS1324.

6. Evaporator Coil

Precision packaged unit shall comprise of cooling coil of copper tubes expanded into aluminium fins with corrugated profile and hydrophilic treatment. Face and

surface areas shall be such as to assure rated capacity and the air velocity across the coil and Filter shall not exceed 2.5 m/s. The cooling coil shall be minimum of 3 rows deep and the fin spacing shall not exceed 1.8 mm. Coil selection to be suitable for SHF > 0.95 and provided with hydrophilic coating to minimize/eliminate water carry over into the airflow stream. Drain pan shall be made of stainless steel.

7. Scroll Compressor

- The compressor shall be of the high efficiency scroll design operating with environment friendly refrigerant and 400V, 3 phase, 50 Hz supply.
- There shall be single or two independent Refrigerant Circuits in the unit. Minimum one of the two compressors should be scroll with inverter controlled brushless DC motor or Digital Scroll (with electronic expansion valve), operating with environment friendly refrigerant and power supply of 400-460V, 3ph, 50-60Hz. The compressor should have integrated thermal overload protection and acoustic hood. The compressor motor control driver is provided with integral electronic protection against over temperature, over current, over or under-voltage with absence of one or more phases. The electronic control of the inverter is provided with automatic soft-start system and continuous control of the compressor curve to prevent and correct its use beyond the maximum allowed limits.
- The second compressor (if two circuit unit) shall be highly efficient scroll type operating with environment friendly refrigerant and power supply of 400-460V, 3ph, 50-60Hz.
- The compressor shall have integrated thermal overload protection.

Crankcase Heater on Compressor should be integral part of the unit.

Compressors, the humidifier shall be isolated from the air flow in the version with downward flow, and in the air flow in versions with upward output. The compressor shall be charged with synthetic oil and designed for operation on environment friendly refrigerant.

8. Refrigeration Circuit

The refrigeration system shall be of the multiple independent circuit direct expansion type and incorporate hermetic scroll compressors, complete with crankcase heaters.

- The refrigerant circuit comprises:
 - Liquid receiver
 - Electronic expansion valve
 - Delivery oil separator
 - Solenoid valve for shutting off the refrigerant liquid
 - Refrigerant liquid flow indicator
 - Solid cartridge free on filter

- Safety valve
- High pressure safety pressure switch with manual reset
- Low pressure switch with automatic reset
- Shut-off valves for external connections (versions with remote condenser)
- Copper refrigerant pipes with anti-condensation insulation on the suction line
- Pipe taps on suction and delivery side and charging valve on liquid side.
- Each Compressor to have its own Evaporator and Condenser.

9. Expansion device: Electronic Expansion Valve (EEV)

- The unit should have Electronic Expansion Valve, which offers the following advantages:
 - Fast, high precision adjustment of refrigerant flow;
 - Fast arrival of the unit at steady-state conditions;
 - Superheating value remains constant in variable thermal load conditions;
 - Efficient operating conditions of the compressor, especially in the presence of low room temperatures;
 - Wide working range with consequent extension of the unit's operating limits. These properties result in enhanced performance of the unit and make it possible to obtain very significant energy savings
- The Pressure transducers attached to the EEV shall be able to display real time pressure (Suction & Discharge) and Superheat on the Microprocessor panel.
- The Temperature Sensor attached to the EEV shall be able to display real time parameters of Refrigerant such as Suction & Discharge Temperature.

10. Air Cooled Condenser

Condenser shall be air-cooled type, suitable for outdoor installation and shall be suitable for operating at high ambient of 45 deg C DBT and at low ambient of up to 0 deg C DBT temperatures. Condenser shall be in copper tube & aluminum fins construction. Condenser coil shall be of maximum 4 rows deep and the fin spacing shall not exceed 2mm. The condenser fan/s shall be of propeller type with max 1310 RPM variable voltage electric motor complete with IP-54 protection. Motor shall be speed controlled to ensure a stable operation for varying ambient; by a factory fitted direct acting head pressure activated step-less Fan Speed Controller or using Electronically Commutated Fan. The condenser shall be complete with provisions for refrigerant piping connections, shut off valves and any other standard accessories necessary with the equipment supplied. Each

Circuit to have its independent set of condenser coil and Fans in separate casing.

The condenser coil should be Epoxy-Coated from OEM factory.

11. Water Sensor:

The system shall be provided with relevant water detection kit which shall have sensors. Each of the sensor must be capable to detect individually any water below the false floor near the unit, the sensor must be connected to the unit microprocessor thus enabling the controller to give an alarm in case of wet floor.

12. Humidifier:

Each packaged unit shall be provided with multistage electric heaters (multistage for more than 5TR Capacity Units) with heating elements constructed from a non-oxidable material. Electric strip heaters shall be of the low temperature totally enclosed strip type fitted with radiation fins and suitable for operating at black heat. If overheating occurs, a safety thermostat should cut off the voltage supply to the heaters and triggers an alarm.

13. De-Humidifier:

De-humidification cycle shall operate by reducing the speed of EC fan to reduce ADP of coil. Hence, by reduction of fan speed there shall be additional power saving.

14. Air Flow Sensor:

The unit should have inbuilt Air Flow Rate Feedback Sensor to display the real time Airflow rate and also to have fan modulation function based on Airflow rate.

15. Supply Air Sensor:

The unit should have inbuilt Supply Air Flow Temperature sensor to show real time Supply Air Temperature on the display of the unit.

16. Microprocessor Control System

Logic Circuitry:

A microprocessor shall continuously monitor operation of each Server room air- conditioning unit continuously digitally display room temperature and room relative humidity, alarm on system malfunction. When more than one malfunction occurs, flash fault in sequence with room temperature, remember alarm even when malfunction cleared, and continue to flash fault until reset.

Microprocessor to control the following functions:

- Ambient temperature
- Speed of the delivery fans
- Humidity (HH versions)
- Speed of the condensation fans

- Timing of compressors with automatic rotation
- Alarm signal on two levels
- Supply fan working status.
- Current date and time.
- Electric heaters working status.
- Manual / Auto unit status.
- Temperature set point.
- Humidity set point.
- Working hours of main component i.e. fan, heater, humidifier
- Unit working hours.
- Modes of operation (cooling, heating, humidification, De-humidification,).
- The last 10 intervened alarms.
- Password for unit calibration values modification.
- Automatic reset of program.
- Cooling capacity control.
- Compressor starting timer
- Date & time of last 10 intervened alarms.
- Start/ Stop status storage by switch
- Controlled automatic reset of high and low pressure alarms

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6.14 FILTER

1.0 General

This section covers the general requirements for special type of filters to be installed in air moving equipment or air ducts.

2.0 Electronic Air Filter

It is the intent of the specification to incorporate highly efficient electronic air filtration system with low pressure drops into the building AHU/TFA/Heat Recovery Units (HRU).

All AHU's/TFA/Heat Recovery Units shall be fitted with a true electronic air cleaner system (complete with washable pre-filter, charging section and collector section) to be installed before the cooling coils. Other forms of air filtration systems such as charged media filters, dielectric media filters, or ionizers (which do not have second stage collector plates) shall not be acceptable. The electronic air cleaner (EAC) shall be capable of removing particulates as small as 0.01 microns including microscopic haze particles, smoke, dust, mould spores and bacteria.

Central Air Cleaner, a hybrid air purification system, should improve the indoor air quality by reducing harmful pollutants like particulate matter (PM_x), PM 2.5, allergens, pollen, smoke, bacteria, pathogens based on Electrostatic precipitation technology. Other forms of air filtration systems such as charged media filters, dielectric media filters, or ionizers (which do not have second stage collector plates) shall not be acceptable. It should be a monobloc structured unit specifically designed for integration in Return Air path of the AHU, to centrally capture the pollutants. It should be equivalent to MERV14 efficiency @ 2000 cfm with low pressure drop of not more than 65Pa @ 492fpm (certification for the same to be provided). It should be UL certified within built provision to connect to BMS. The product has to be certified as a green product by any of the Green Building councils across the world.. The central air cleaner units must have a valid ANSI/ASHRAE 52.2 test report to verify filtration efficiency. The unit must have factory test report to ensure that it meets the following safety and environmental criteria with reference to ES164468, UL 867 and DA 6.2.1. Ozone level of units provided must be within the acceptable limit of 0.05ppm. The units shall have local LEDs at each individual unit to indicate when the units are up for wash/malfunctioning.

Approvals / Code Requirements

The EAC shall be Underwriter Laboratories (UL) Listed. The EAC shall also be EMC (Electromagnetic compatibility) certified. Full documentation must be submitted to confirm compliance to the above requirements.

Ozone level of EACs provided must be within the acceptable limit of 0.05ppm. Tenderers must also provide a test report to confirm conformance.

Factory Safety Test Report

The EAC must have factory test report to ensure that it meets the following safety and environmental criteria with reference to ES164468, UL 867 and DA 6.2.1:

Performance Testing

- Dielectric test
- Ambient and voltage extremes
- E-field test
- Oscillatory transient test
- Lightning test
- EFT (fast transients) test
- ESD (high voltage transients) test
- EMI susceptibility test
- EMI radiation test

Environmental

- Humidity
- Condensation
- Vibration

All tenderers must submit a design analysis conditional qualification test report to confirm that tests have been conducted based on the above criteria and that the EAC has passed these tests.

Safety Provisions

Each EAC cell shall have their automatic interlock switch which disconnects power and discharges the cell when the access door is opened. In addition, the EAC shall be capable of interlocking when disconnecting the power to each individual EAC unit, or when the AHU fan is not running.

A high voltage test button shall be provided for each individual high tension power supply unit to indicate the presence of high voltage on the electronic cells. An overall test button for a group of power supply units to provide a general indication of high tension voltage is not approved.

Performance / Reliability Requirements

The average capacity of the EAC shall be at least 1000cfm for the single cell unit and 2000cfm for the double cells unit.

The initial atmospheric dust spot efficiency (ASHRAE 52-76) of the EAC shall be at least 67% at 2000cfm and up to 95% at 800cfm. The proposed equipment shall be capable of capturing sub-micron particulates/contaminants down to 0.3 microns. All tenderers shall submit test results of filtration efficiency by Air Filter Testing Laboratories for efficiency verification.

The solid state power supply shall provide dual voltage to the ionizer and collector section. The voltage to the ionizer shall be at least 8000V/6400V DC to create an intense electrostatic field to allow maximum transfer of electrical charge from the ionizing wires to air particles. The voltage to the collector shall be at least 4000V/6400V DC.

For the EAC to perform effectively against PM 2.5 pollutants, the EAC shall have a fractional efficiency test report from a third-party testing laboratory to confirm CME (Composite Minimum Efficiency) of the following:

<u>Particle Size</u>	<u>CME</u>
0.3 to 0.4 µm	68%
1.0 to 1.3 µm	89%
2.2 to 3.0 µm	94%

The entire Filtration system shall be washable and reusable without need for replacements. Electrostatic media filters that collect particles on disposable media pads shall not be acceptable.

The average initial pressure differential drop across the entire filtration system shall not exceed 65 pa at 2000cfm and 2.5 m/s airflow. The tungsten ionizing wires and aluminum collector plates shall be integrated within one pack. It shall be washable for repeated use. A washable aluminium mesh prefilter shall be provided at the inlet to trap all larger sized particles.

Filter cells shall be universal to allow for a single inventory of filters as spare parts.

The EAC shall be completed with Hot- dipped Galvanized cabinet to protect against rust, heavy duty commercial used electronic cells, solid state power supply, protective screen and prefilter. A washable aluminium mesh prefilter shall be provided at the inlet to trap all larger sized particles.

The EAC shall have the capability for the optional addition of activated carbon (Charcoal) filter for the removal of gaseous contaminants and odours. The activated carbon filter shall be able to reside into the EAC cabinet as and when necessary; no modification for the initial installation shall be allowed.

Diagnostics / Interfacing to Building Management System

The EAC shall have the capability of interface with the building management system through a Solid State Performance Indicator (SSPI). The following status shall be allowed for remote monitoring by the building management system as common fault:

1. Normal operation of solid state power supply (ON)
2. Any malfunction of the system that shall cause an alarm activation (CHECK)
3. Excessive dirt accumulation in the collector cells that could result in the reduction of the EAC performance (WASH)

The EAC shall have local LEDs at each individual unit to indicate the above status and it shall be able to provide in addition a signal to link-up with the building management system for monitoring.

Submission of Compliance Documentation

Tenderers must submit a Clause-by-Clause Compliance Summary and provide full documentation/ technical literature/data sheets/reports to confirm compliance for each clause. Please also submit a project reference list.

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6.15 FANS

1. SCOPE

The scope of this section comprises the supply, erection, testing and commissioning of centrifugal, axial, in-line and propeller type fans conforming to these Specifications and in accordance with the requirement of system design.

2. TYPE

Centrifugal, in-line, propeller fans and Axial fans shall be of the type as approved of design/ engineer in charge.

3. CAPACITY

The air-moving capacity of fans shall be as shown on approved shop Drawings approved by Engineer-In-charge in consultation with AAI.

4. CENTRIFUGAL FAN

Centrifugal fan shall be DIDW /SISW Class I construction arrangement 3 (i.e. bearings on both the sides) for DIDW/SISW fans complete with squirrel-case induction motor, V-belt drive, belt guard and vibration isolators, direction of discharge / rotation, and motor position shall be as per the Approved for Construction shop drawings.

- a. Housing shall be as per OEM standard design and shall be of airtight permalock construction. It shall be rigidly reinforced and supported by structural angles. Housing for fan size bigger than 1250 mm dia shall be made out of continuously welded heavy gauge steel and will be made in split casing.
- b. 18 gauge galvanized wire mesh inlet guards of 5 cm sieves shall be provided on both inlets. Housing shall be provided with standard cleanout door with handles and neoprene gasket. Rotation arrow shall be clearly marked on the housing.
- c. Fan Wheel shall be backward-curved non-over loading type. Fan wheel and housing shall be statically and dynamically balanced. For fans upto 450 mmdia, fan outlet velocity shall not exceed 550 meter/minute. For fans above 450 mm dia, the outlet velocity shall be within 610 meter/minute. High staticpressure fan speed shall be as per manufacturer.
- d. Shaft shall be constructed of steel, turned, ground and polished.
- e. Bearings: shall be of the sleeve/ ball-bearing type mounted directly on the fan housing. Bearings shall be designed especially for quiet operation and shall be of the self-aligning, oil/ grease pack pillow block type.
- f. Motor: Fan motor shall be as per GRIHA 5star requirement & super ECBC requirement and suitable for $415 \pm 10\%$ volts, 50 cycles, 3 phase AC power supply, squirrel-cage, totally enclosed, fan-cooled motor, provided with class F insulation, and of approved make. Motor shall be designed especially for quiet operation. The fan and motor combination selected for the particular required

performance shall be of the most efficient (smallest horse power), so that sound level is lowest.

- g. Drive to fan shall be provided through belt with adjustable motor sheave and a standard belt guard. Belts shall be of the oil-resistant type.
- h. Vibration Isolation: MS base shall be provided for both fan and motor, built as an integral part, and shall be mounted on a concrete foundation through vibration isolators. The concrete foundation shall be at least 15 cm above the finished floor level, or as shown in approved for construction shop drawings.
- i. Centrifugal fans shall be shaft driven external belt drive and motor.
- j. Fan shall conform to AMCA standard 211 and 311. Fan must be tested in accordance with ANSI/AMCA standard 210-99 and AMCA standard 300-96 in an AMCA accredited laboratory. Fans shall be certified to bear the AMCA label for air and sound performance.

5. AXIAL FLOW FANGENERAL

- a. Fans shall be of the type, size, arrangement and capacity as shown on the drawings.
- b. Unless specified, fan performance rating data shall be tested accordance with AMCA Standard 210-85(Air Moving and Conditioning Association).
- c. A computer printout of fan performance rating corresponding to the AMCA licensed data, with corrected ratings for altitude and temperature, fan operating speed, bearing life, etc. shall be submitted for approval.
- d. All fans shall be dynamically trim-balanced to ISO1940 or AMCA 204/3 - G2.5 quality grade after assembly. A computer printout with the vibration spectrum analysis shall be attached to the fans.
- e. Fan motors shall comply in all respects with continuous rating in accordance with IS/ IEC34 or equivalent. Motor bearings shall be of ball or rollertype, grease or lubricant sealed for life. Fan and drive shall be earthed to prevent accumulation of static charge.
- f. Fans shall be installed at staircase or lobby where fresh air intake is free from any obstruction and shall be energized only by fire alarm system. Fan shallbe of Axial Flow Fan. Protective grille at the suction of the fan is required.
- g. Fans for elevated temperature (Smoke Extraction Fans) with components rated for high temperature (250C, 2Hrs) service, with belt drive assemblies exposed to the air stream are not acceptable.
- h. For Smoke Extraction Fans where motor is in the air stream with electrical/electronic temperature limit switch for motor protecting shall not be used.
- i. Fan should be of G.S.S, the Steel sheet should be JFE Galva zinc (Base metal cold rolled), JIS G3302, SGCC with Z22 (minimum coating weight on both

sides @ 220 g/m²) zinc coating & Zero Spangle, skin passed, chromated and dry or powder coated MS casing.

- j. If fan is open to atmosphere, Fans shall be with pure polyester powder coating for minimum thickness of 60 microns.
- k. Fan shall be AMCA certified for Air performance and Fan Efficiency Grade (Min FEG 71, lesser is not acceptable).
- l. Thickness of Axial fan's casing shall be as per OEM standard design.
- m. Smoke and heat exhaust fans are required to be in compliance with the CE/UL labelled/ 'BSEN12101-3:2015'. This requires the fan to be subjected to a rated temperature of 250C for a rated duration of 120 minutes

For Pressurization and other services:

- a. Outlet velocity of the fans should not exceed 16m/s.
- b. RPM as per OEM best selection to meet efficiency and noise criteria.
- c. Sound level for fans should not exceed 80DB (A) @ 3 meter (Room Condition).

Except following specifications, rest of the specification shall be as per specifications mentioned in CPWD Specifications for HVAC works ' 2017 amended up to date.

AXIAL FLOW FANS

- a. Single Piece Long Casing (Motor should completely be accommodated inside the fan casing) Axial Fans shall be licensed to bear the AMCA Seal. Multi piece casing is not accepted.
- b. To achieve the minimum and equal clearance between the blade tips and casing, tube casing shall maintain its roundness by means of using one piece of sheet metal with 90 edges flanging up.
- c. Fan motor base support shall be properly secured (locked and sealed) to the fan housing and be of adjustable type to have precise control of motor shaft central position as well as running clearance between blade tips and casing. Motor (KW/HP) shall be able to be changed or upgraded at site without changing fan housing or ducting construction.
- d. Fans supplied shall be complete with factory fabricated mounting bracket (ceiling or foot mounted) and suction/discharge matching flanges as accessories.
- e. All hubs shall be cast Aluminum or Aluminum alloy (Grade LM2) unless for Smoke Extractor Fans where high temperature (250C/2Hrs) air is expected then Aluminum alloy or steel fan impeller blades are required. Otherwise impeller blade material with Polypropylene (PP), Glass-reinforced Polypropylene (PPG) and Glass-reinforced Polyamid (PAG), to provide selfbalancing, anti-static, anti-sparking characteristic is preferable.
- f. Running clearance between blade tips and casing shall not exceed 1% of the impeller diameter and 2% for smoke spill high temperature fan where mechanical expansion coefficient is different from normal ambient temperature.

Fan manufacturer shall provide the fan assembled with the same clearance between blade tips and casing of the tested prototype. Note that the air performance and pressure loss are greatly affected by this clearance.

- g. Impellers shall be secured to the drive shaft by a key and keyway. Axial location shall be provided by a collar or shoulder on the drive shaft together with a retaining washer and screw fitted into a tapped hole at the end of the shaft and locked in position. Blades shall be secured in place to the angle setting by setscrews, locking nuts or setting pins.
- h. Fan motor shall be totally enclosed and external terminal box of at least IP55 shall be provided
- i. All fans after assembly shall be dynamically trim-balanced to ISO1940 or AMCA 204/3 - G2.5 quality grade. A computer printout with vibration spectrum analysis shall be attached to the fans.
- j. For vanes Axial, Fan Casing should be provided with Special Designed Integral Straightening Vanes to reduced turbulence provide high performance & low noise level.
- k. Motor shall be as per GRIHA 5star requirement & super ECBC requirement, totally enclosed, fan cooled standard round frame, constant speed, continuous duty, single winding, suitable for 415+ 10% volts, 50 cycles, 3 phase AC power supply, provided with class 'F' / 'H' insulation with IP54/IP55 protection. Motor shall be specially designed for quiet operation. For lowest sound level, fan shall be selected for maximum efficiency or minimum horsepower. Motor conduit box shall be mounted on exterior of fan casing and lead wires from the motor to the conduit box shall be protected from the air stream by enclosing in a flexible metal conduit /vanes.
- l. The Axial Fan Blades shall be of Cast Aluminum or Aluminum alloy of aero foil design for high efficiency and high static pressure. The blades shall be joined together on cast aluminum hub.
- m. The mounting ring shall be of CRCA/sheet steel with steel brackets to connect the frame, with the Fan/Motor assembly. Rubber mounts shall be provided between the mounting frame and the mounting brackets.
- n. In case of fire the exhaust fans & motor shall be suitable for operation at minimum 250 deg C. for 2 hours & shall be CE/UL labelled /EN certified.
- o. Fan blade shall be as per OEM standard design.
- p. Accessories : The following accessories shall be provided with all fans**
 - q.1) Fire rated Canvas flexible connection as required.
 - q.2) Gravity Louver.
 - q.3) Bird Screen.
 - q.4) Vibration isolation: The assembly of fan and motor shall be suspended from the slab by vibration isolation suspension of rubber-in-sheet type.
 - q.5) TP isolator of suitable capacity with its enclosure shall be provided.

- q.6) Nuts, bolts, shims etc. as required for the grouting of the equipment.
- q. Fan shall be factory assembled and shipped with all accessories factory mounted.

6. PROPELLER FAN

Propeller fan shall be direct-driven, multiple blade type, mounted on a steel mounting plate with orifice ring.

- a. Mounting Plate shall be of steel construction, square with streamlined venturi inlet (reversed for supply applications) coated with baked enamel paint or with min 220gsm zinc coating. Mounting plate shall be of standard size depending upon the fan size as per OEM. Orifice ring shall be correctly formed by spinning or stamping to provide easy passage of air without turbulence and to direct the air stream.
- b. Fan Blades shall be constructed of aluminium or steel. Fan hub shall be of heavy welded steel construction with blades bolted to the hub. Fan blades and hub assembly shall be statically and dynamically balanced at the manufacturer's works.
- c. Shaft shall be of steel, accurately ground and shall be of ample size for the load transmitted and shall not pass through first critical speed thru the full range of specified fan speeds.
- d. Motor shall be energy efficient standard (easily replaceable) permanent split capacitor or shaded pole for small sizes, totally enclosed with prelubricated sleeve or ball bearings, designed for quiet operation as per approved design for $220 \pm 10\%$ volts, 50 cycles single phase power supply / $415 \pm 10\%$ volts, 50 cycles three phase power supply.
- e. Accessories : The following accessories shall be provided with propeller fans:
 - i. Wire guard on inlet side and bird-screen at the outlet.
 - ii. Fixed or gravity louvers built into a steel frame at the outlet.

7. INLINE FANS

7.1 Circular Inline Fans

Circular inline Centrifugal duct fan shall be a straight through radial fan. It should be compact. Motor shall be energy efficient.

The fan shall cope with high pressure and long duct runs, whilst still operating at an acceptable sound level.

The circular inline fans should be moisture resistant and should be approved for installing in humid or damp environments. The fans should be rated IP-44 when installed in a duct system. The casing should be manufactured from pre galvanized steel. Automatic thermos- contact shall open up if the temperature

within the motor windings becomes excessive. Fan should be equipped with external rotor single phase asynchronous motor.

7.2 Cabinet Inline Fans (Above 1000 CFM capacity)

The Cabinet of the cabinet inline fans should be manufactured in galvanized steel & shall be with insulated housing for lower noise levels. The Mounting brackets and access panel should be fitted as per manufacturer standard. The impeller of the fans should be with high efficiency forward/backward curved DIDW/SISW type. The scroll of the fans should be fabricated with galvanized sheet steel. The motor of the fans shall be Squirrel cage induction type with bearings sealed for life. The motor shall be energy efficient suitable for single phase electrical supply. The cabinet of the fan shall be of double skin construction with acoustically lined with 25 mm glass wool with perforated GI sheet from inside. Fan noise level shall not be more than 60dBA at 3 meters distance in hemispherical reverberant room conditions.

8. PERFORMANCE DATA

All fans shall be selected for the lowest operating noise level. Capacity ratings, power consumption, with operating points clearly indicated, shall be submitted and verified at the time of testing and commissioning of the installation.

9. TESTING

Capacity of all fans shall be measured by an anemometer. Measured air flow capacities shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current.

10. INSTALLATION

- a. The EPC Contactor shall supply all required bolts, base frame (wherever required), vibration isolators any other accessories and shall assure that the components are placed securely in proper position.
- b. Vibration isolators shall be provided with an efficiency of not less than 80%.

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6.16 ENERGY METERING SYSTEM (BTU METER)

Parameter	Technical Specification
Type	Ultrasonic BTU Meter/ Flow meter
Service	For both clear water and dirty water upto a maximum pressure of 1.6MPa for accurate thermal energy measurement of a liquid-based thermal energy production/ transferring system No Interference by any magnetic interference.
Liquid Types	Virtually all commonly used liquids (full pipe)
Liquid Temp	-25° C ~ 95°C or -25° C ~ 130°C, depending on transducertype
Liquid Suspension concentration	<20,000ppm, or, < 2%, particle size smaller than 100um.
Pipe Type	All metals, most plastics, fiber glass, etc. Allow pipe liner
Sensors	Two PT1000 sensors, which shall be immersion mounting type, to measure the temperature of the supply flow and the return flow. The energy consumption rate to be calculated based on the temperature difference and the measured flow rate. A built-in energy totalizer shall be used to add up the amount of energy delivered.
Repeatability	Better than 0.2%
Accuracy	For flow measurement: +/-1% of reading, plus +/- 0.006m/s ; (+/- .02ft/s) in velocity
Response Time	0.5s. Configurable between 0.5s and 99s
Velocity	-16 ~ +16m/s ; *(-52 ~ +52 ft/s), bi-directional
Recording	Automatically records the totalizer data of the last 128 days
Local Meter Display	LCD with backlight. 2 x 20 letters. 4 x 4 tactile-feedback membrane keypad.
	Displays instantaneous energy rate, total energy (positive, negative and net), temperatures, flow rate, time, analog inputs, flow velocity, etc.
Signal Outputs	Communication: Isolated RS-485 with power surge protection. Should support the M-BUS or MODBUS protocol.
Power Supply	3.6V Lithium Battery, Minimum 6 year life.

Mounting	On Straight chilled water return pipe, longer than 15D, where D is pipe diameter. If a pump or a valve is nearby upstream, the straight pipe section following the pump should be > 25D.
Enclosure	IP65 weather resistant.
Make & Model offered	Vendor to Furnish complete code

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6.17 AIR DISTRIBUTION (FACTORY FABRICATED DUCTS)

1. SCOPE

This section comprises of supply, fabrication, installation and testing of all sheet metal ducts and supply, installation, testing and balancing of grilles, registers and diffusers, in accordance with these specifications.

2. MATERIAL

2.1. Ducts

i) All ducts shall be fabricated from Galvanised Sheet Steel (GSS) conforming to IS: 277. The steel sheets shall be hot dip galvanized with MAT finish with coating of minimum 120 grams per square meter (GSM) of Zinc, GI sheets shall be lead free. Eco friendly and RoHS compliant.

ii) The thickness of sheets for fabrication of rectangular ductwork shall be as under. The thickness required corresponding to the longest side of the rectangular section shall be applicable for all the four sides of the duct work.

Longest side (mm)	Minimum sheet thickness
	For GSS
750 mm and below	0.63
751 mm to 1500 mm	0.80
1501 mm to 2250 mm	1.00
2251 mm & above	1.25

(iii) Thickness of sheet for Round Ducts

Diameter of duct, mm	Thickness of Sheet, mm
	GI sheets
150 to 500	0.63
501 to 750	0.80
751 to 1000	0.80
1001 to 1250	1.00
1251 and above	1.25

iv) All sheet metal connections, partitions and plenums required for flow of air through the filters, fans etc. shall be at least 1.25 mm thick galvanised steel sheets, in case of G.I. sheet ducting or 1.8 mm thick aluminium sheet, in case of aluminium sheet ducting and shall be stiffened with 25 mm x 25 mm x 3 mm angle iron braces.

v) Circular ducts, where provided shall be of thickness as specified in IS: 655 as amended upto date.

vi) Aluminium ducting shall normally be used for clean room applications, hospitals works and wherever high cleanliness standards are functional requirements.

2.2 Associated Items

- Supply/return air outlets, F.A. grilles and accessories shall be constructed from extruded aluminium sections.
- Flanges for matching duct sections, stiffening angles (braces) and supporting angles shall be of rolled steel sections, and shall be of the following sizes.

Application	Duct Width	Angle size
Flanges	Upto 1000 mm	35 mm x 35 mm x 3 mm
-do-	1001 mm to 2250 mm	40 mm x 40 mm x 3 mm
-do-	More than 2250 mm	50 mm x 50 mm x 3 mm
Bracings	Upto 1000 mm	25 mm x 25 mm x 3 mm
-do-	More than 1000 mm	40 mm x 40 mm x 3 mm
Support angles	Upto 1000 mm	40 mm x 40 mm x 3 mm
-do-	1001 mm to 2250 mm	40 mm x 40 mm x 3 mm
-do-	More than 2250 mm	Size and type of RS section shall be decided in individual cases

2.3 CONSTRUCTION

2.3.1 Ducts

2.3.1.1 Ducts shall be fabricated at site or factory fabricated and shall be generally as per IS: 655 "Specifications for metal air ducts", unless otherwise deviated in these General Specifications.

2.3.1.2 The interior surfaces of the ducting shall be smooth.

2.3.1.3 All the ducts upto 600 mm longest side shall be cross broken between flanges by a single continuous breaking. Ducts of size 600 mm and above shall be cross broken by single continuous breaking between flanges and bracings. Alternatively, beading at 300 mm centres for ducts upto 600 mm longest side, and 300 mm centres for ducts above 600 mm size shall be provided for stiffening.

2.3.1.4 As far as possible, long radius elbows and gradual changes in shape shall be used to maintain uniform velocity accompanied by decreased turbulence, lower resistance and minimum noise. The ratio of the size of the duct to the radius of the elbow shall be normally not less than 1:1.5.

2.3.1.5 Flanged joints shall be used at intervals not exceeding 2500 mm. Flanges shall be welded at corners first and then riveted to the duct.

2.3.1.6 Stiffening angles shall be fixed to the sides of the ducts by riveting at 1.25 meters from joints for ducts of size 600 mm to 1500 mm, and 0.6 m from joints for ducts of size larger than 1500 mm. Bracings for ducts larger than 1500 mm can alternatively be by diagonal angles.

2.3.1.7 Plenums for filters shall be complete with suitable access door of size 450 mm x 450 mm.

2.3.1.8 All factory fabricated duct shall be supplied in L sections, the length of any piece shall not be more than 1800 mm for duct with longest side of cross section as 600 mm and above and 3000 mm for rest.

2.3.2 Air Outlet and Inlets (Supply and Return)

2.3.2.1 All air outlets and intakes shall be made of extruded aluminium sections & shall present a neat appearance and shall be rigid with mechanical joints.

2.3.2.2 Square and rectangular wall outlets shall have a flanged frame with the outside edges returned or curved 5 to 7 mm and fitted with a suitable flexible gasket between the concealed face of the flanges and the finished wall face. The core of supply air register shall have adjustable front louvers parallel to the longer side to give upto 22.5 degrees vertical deflection and adjustable back louvers parallel to the shorter side to achieve a horizontal spread air pattern to at least 45 degrees. Return air grilles shall have only front louvers. The outer framework of the grilles shall be made of not less than 1.6 mm thick aluminium sheet. The louvers shall be of aerofoil design of extruded aluminium section with minimum thickness of 0.8mm at front and shall be made of 0.8mm thick aluminium sheet. Louvers may be spaced 18 mm apart.

2.3.2.3 Square and rectangular ceiling outlets/intakes shall have a flange flush with the ceiling into which it is fitted or shall be of anti smudge type. The outlets shall comprise an outer shell with duct collar and removable diffusing assembly. These shall be suitable for discharge in one or more directions as required. The outer shell shall not be less than 1.6 mm thick extruded section aluminium sheet. The diffuser assembly shall not be less than 0.80 mm thick extruded aluminium section.

2.3.2.4 Circular ceiling outlets/intakes shall have either flush or anti smudge outer cone as specified in the tender specifications. Flush outer cones shall have the lower edge of the cone not more than 5 mm below the underside of the finished ceiling into which it is fitted. Anti smudge cones shall have the outer cone profile designed to reduce dirt deposit on the ceiling adjacent to the air outlet. The metal sheet used for construction of these shall be minimum 1.6 mm thick extruded aluminium sheet.

2.3.2.5 Linear diffusers shall have a flanged frame with the outside edges returned 3.5 mm and shall have one to four slots as required. The air quantity through each slot shall be adjustable. The metal sheet used for the construction of these shall be minimum 1.6 mm thick extruded aluminium sheet.

2.3.2.6 Grilles and diffusers constructed of extruded aluminium sections shall have grille bars set straight, or deflected as required. These shall be assembled by mechanical interlocking of components to prevent distortion. These grilles and

diffusers shall have a rear set of adjustable blades, perpendicular to the face blades for deflection purposes.

- 2.3.2.7 All supply air outlets shall be fitted with a volume control device, made of extruded aluminium gate section. The blades of the device shall be mill finish/ block shade pivoted on nylon brushes to avoid rusting & rattling noise, which shall be located immediately behind the outlet and shall be fully adjustable from within the occupied space without removing any access panel. The volume control device for circular outlets shall be opposed blade radial/shutter type dampers, or two or more butterfly dampers in conjunction with equalizing grid. Opposed blade dampers shall be used for square and rectangular ceiling/wall outlets and intakes.
- 2.3.2.8 All the products supplied by contractor should supplement in performance by selection curves of product ratings from the manufacturer.

3. Displacement Diffusers

Construction Standards

The displacement diffusers are circular architectural design elements of 360° or 180° construction for free-standing installation. The diffusers should of low-turbulence air supply with jet velocities. Displacement flow diffusers should be consist of a casing with a spigot at bottom, the bottom spigot model configuration includes a lip seal. A spigot mounted Volume control damper should be fixed. The discharge faces are of perforated sheets concealing an air straightener and an interior air control element.

Material

Top cover, base, spigots and side plates should be made of SS 304/316. The surface should be of stainless steel finish. The circular surface should be made out of 2mm thick SS304/316 perforated sheet with 6mm dia X 9mm staggered pitch for air discharge and 3mm thick SS304 stiffener ring, stitch welded from inside for the reinforcement. The air straightener will be made of plastic; the air control element should be made of synthetic fiber and the lip seal of rubber. The surface finish should be made as per interior requirement.

4. JET DIFFUSER

Jet diffusers shall be designed to handle high air flow rates and provide relatively long throws which makes them particularly suitable for conditioning of large spaces such as halls, auditoria, terminal buildings. The diffusers shall be versatile in application by virtue of the novel “reversible and rotatable” core design which allows the air jet to be adjusted for both pattern and deflection. Units may be mounted individually or in banks in bulkhead arrangements or directly into stub ducts.

Units shall be constructed from aluminium spinings supported on a studding and spacer assembly. The core may be rotated through 180 degrees to expose either a straight or diffused core assembly. In addition, the diffuser spigot may be rotated within the mounting plate (if supplied) to enable a full 360 degree adjustment, by releasing the tension bolts.

It should have following Features:

- Simple and effective air diffusion for large spaces.
- Long throw characteristics.
- High air handling capacity.
- Easy to install and adjust.
- Reversible core to produce long throw jet or short throw diffuser patterns.
- Core rotatable through 360 degrees for “eyeball” jet direction.
- Jet may be deflected off axis by up to 15 degrees.

The **JET NOZZLE** shall be aerodynamically designed powder coated aluminium construction double skin eye ball type with double flap butterfly damper, mounted on steel face plate suitable for side wall installation. Nozzle shall be deep drawn in one single pcs with discharge nozzle and face cover ring crimped on nozzle base to avoid the misplacing of ring problem. The Nozzle shall be housed in a specially designed housing with a mounting flange with holes for fastening the nozzle and aesthetic trim ring with snap locking arrangement to cover fasteners and give blemish free appearance. The color shade shall be as desired by Client/Architect/AAI.

Type- jet nozzles eye ball

Draft length - 30mtr (as per requirement) Deflection ' 0 to 40 degree

Type of finish ' powder coated Noise level ' 30 NC

Housing ' aluminum finish with snap locking face ring

5. FRESH AIR INTAKES

- 5.1** Fresh air intake grills shall be made of extruded aluminium sections.
- 5.2** A flanged frame using RS sections shall be provided on front face to conceal the gap between the louvers and the adjoining wall face. Corners of frame shall be welded. The frame shall be made structurally rigid.
- 5.3** Louvers made from extruded aluminium section shall be in modular panel form for ease of handling. These shall be free from waves and buckles. Vertical blades shall be truly vertical and horizontal blades shall be truly horizontal. Butt joints in blades shall not be accepted.
- 5.4** Additional intermediate equally spaced supports and stiffeners shall be provided to prevent sagging/ vibrating of the louvers, at not more than 750mm centres where the louver's length is longer than 750mm.
- 5.5** A bird wire screen made of 12 mm mesh in 1.6 mm steel wire held in angle or channel frame shall be fixed to the rear face of the louver frame by screens.

6. FIRE DAMPERS

- i) Fire dampers shall be provided in all the supply air ducts and return air ducts (where provided), return air passage in the air-handling unit room and at all floor crossings.

Access door will be provided in the duct before each set of fire dampers.

- ii) Fire dampers shall be multi blade louvers type. The blade should remain in the air stream in open position & shall allow maximum free area to reduce pressure drop & noise in the air passage. The blades and frame shall be constructed with minimum 1.6mm thick galvanised sheet & shall be factory fitted in a sleeve made out of 1.6mm galvanised sheet of minimum 400mm long. It shall be complete with locking device, motorised actuator & control panel.
- iii) Fire dampers shall be motorised smoke & fire dampers type. It shall be supplied with spring loaded IS/ UL stamped fusible link to close fire damper in the event of rise in duct temperature. Fire damper shall also close on receipt of fire alarm signal to cut off air supply instantaneously. An electric limit switch shall also be operated by the closing of fire damper, which in turn shall switch off power supply to AHU blower motor as well as strip heaters.
- iv) Fire dampers shall be I S / CBRI/UL tested & certified for 90 minutes rating against collapse & flame penetration as per IS/UL 555-1995 (Under writers laboratories)
- v) Fire dampers shall be compatible with the fire detection system of building & shall be capable of operating automatically through an electric motor on receiving signal from fire alarm panel.
- vi) Necessary wiring from fire alarm panel up to AHU electric panel shall be provided by the department & further from AHU electric panel to fire damper shall be provided by air conditioning contractor.

7. VARIABLE AIR VOLUME (VAV) BOXES

- i) These shall be of the low velocity variable air volume boxes without re-heat coils, and shall be of open protocol as marketed by a firm specializing in this field. The contractor shall supply and install units to the quantity and locations as specified.
- ii) The unit shall be complete with damper, airflow ring, and solid state electronic controls to provide accurate room temperature control. The damper shall be aero foil type construction with bearings.
- iii) Boxes shall be supplied with all internal attenuation treatment and acoustical damped casing necessary to achieve the required noise criteria. Casing shall be of 22G GSS minimum fitted with a completely sealed, easily removable means of access to all internal parts. Access to all boxes must be from the underside only.
- iv) The actuator shall be of 24V AC Bi-directional, direct coupled to the damper shaft. The required transformer to step down of the voltage range from

230V to 24V shall be part of the unit. The power point with an isolator near the VAV will be provided by other agencies.

- v) The unit shall be complete with transformer, access panel and other accessories as per the standard.
- vi) The noise level shall be less than 35dbA.
- vii) Maximum allowable static pressure to the boxes for its satisfactory operation shall not exceed 0.10WG, otherwise fan and motor selections may be affected
- viii) Boxes shall be able to reset any air flow between 10% and the maximum air quantity that the boxes can handle without changing orifices or other parts. Air quantity limiters will not be accepted.
- ix) A suitable device shall be provided for the field adjustment of minimum airflow. All boxes shall be initially factory set at minimum air quantity of 10% and maximum quantity of 110% of the design requirements.
- x) Under shut-off conditions, all boxes shall not have air leakage more than 2% of the maximum air quantity at 75mm static pressure.
- xi) The VAVs shall be used in standalone mode complete with its own temperature sensor and controller and shall perform the function of maintaining the temperature and airflow.
- xii) Where ever specified, the VAVs shall be BMS compatible to enable to network the VAVs to a Network Control Unit and onto BMS. In this mode all VAV data shall be available at the BMS workstation and it shall be possible to change set points and flow settings from the BMS workstation. All such controllers used for the control of VAV boxes shall be compliant with BACnet/ MODBUS protocol and be freely communicable to third party BACnet/ MODBUS IP controllers.
- xiii) All boxes shall be electrically controlled. The boxes shall be pressure independent.
- xiv) VAV Box shall have provision to support from floor/ wall/ ceiling and in vertical /horizontal condition.

8. PERFORMANCE DATA

All data shall be for the diffuser set for zero degree deflection and operating under isothermal conditions in either “jet” or “diffuser” pattern. Correction factors for 15 degree deflection shall be as given below.

NR Level = Peak level on

NR curves based on SWL re 10-12W less 8 dB room absorption.

Throw = Forward distance to the point where the jet velocity has retarded to a terminal velocity of 0.5 m/s.

Ps = Static pressure loss (Pa).

9. Air Outlet and Inlets (Supply and Return)-GRILL/ DIFFUSER

All air outlets and intakes shall be made of extruded aluminium sections & shall present a neat appearance and shall be rigid with mechanical joints. Square and

rectangular wall outlets shall have a flanged frame with the outside edges returned or curved 5 to 7 mm and fitted with a suitable flexible gasket between the concealed face of the flanges and the finished wall face. The core of supply air register shall have adjustable front louvers parallel to the longer side to give upto 22.5 degrees vertical deflection and adjustable back louvers parallel to the shorter side to achieve a horizontal spread air pattern to at least 45 degrees.

Return air grilles shall have only front louvers. The outer framework of the grilles shall be made of not less than 1.6 mm thick aluminium sheet. The louvers shall be of aerofoil design of extruded aluminium section with minimum thickness of 0.8mm at front and shall be made of 0.8mm thick aluminium sheet. Louvers may be spaced 18 mm apart.

Square and rectangular ceiling outlets/intakes shall have a flange flush with the ceiling into which it is fitted or shall be of anti smudge type. The outlets shall comprise an outer shell with duct collar and removable diffusing assembly. These shall be suitable for discharge in one or more directions as required. The outer shell shall not be less than 1.6 mm thick extruded section aluminium sheet. The diffuser assembly shall not be less than 0.80 mm thick extruded aluminium section.

Circular ceiling outlets/intakes shall have either flush or anti smudge outer cone as specified in the tender specifications. Flush outer cones shall have the lower edge of the cone not more than 5 mm below the underside of the finished ceiling into which it is fitted. Anti smudge cones shall have the outer cone profile designed to reduce dirt deposit on the ceiling adjacent to the air outlet. The metal sheet used for construction of these shall be minimum 1.6 mm thick extruded aluminium sheet.

Linear diffusers shall have a flanged frame with the outside edges returned 3.5 mm and shall have one to four slots as required. The air quantity through each slot shall be adjustable. The metal sheet used for the construction of these shall be minimum 1.6 mm thick extruded aluminium sheet.

Grilles and diffusers constructed of extruded aluminium sections shall have grille bars set straight, or deflected as required. These shall be assembled by mechanical interlocking of components to prevent distortion. These grilles and diffusers shall have a rear set of adjustable blades, perpendicular to the face blades for deflection purposes.

All supply air outlets shall be fitted with a volume control device, made of extruded aluminium gate section. The blades of the device shall be mill finish/ block shade pivoted on nylon brushes to avoid rusting & rattling noise, which shall be located immediately behind the outlet and shall be fully adjustable from within the occupied space without removing any access panel. The volume control device for circular outlets shall be opposed blade radial /shutter type dampers, or two or more butterfly dampers in conjunction with equalizing grid. Opposed blade dampers shall be used for square and rectangular ceiling/wall outlets and intakes.

All the products supplied by contractor should supplement in performance by selection curves of product ratings from the manufacturer.

Laminar supply air diffusers shall be made of 2mm thick powder coated aluminium sheet duly insulated with 5mm thick closed cell polyethylene foam insulation having factory laminated aluminium foil and joints covered with self adhesive aluminium tape and having holes 2/3 mm dia including frame work.

10. SS VERTICAL RISER:

It is made by Stainless steel (304) for supplying of cooled air through jet nozzles, which jet nozzles shall place on riser edges and will be connect through supply air duct. Jet nozzles shall be installed at above side on this Vertical Riser and return intake will done from riser bottom. This vertical riser shape can be round or elliptical as per aesthetically requirement.

11. DRUM LOUVER WITH OPPOSED BLADE DAMPER:

The Drum louvers shall be designed to supply high air volumes for the airport application. These shall be designed for the high air volumes on the wall or may be on duct installation. The drum louver shall be made out of extruded aluminium with 40mm thick border. The drum louver should be adjusted in vertical plane. It could be rotate in 30 Deg upwards or downwards movement. The internal guide vanes fitted to drum louver should be adjustable in lateral direction. The drum louver shall be powder coated and color shade shall be as desired by AAI. The aerodynamic and acoustic performance shall be as per ISO5219 and ISO3741.

12. OUTSIDE AIR LOUVERS

Exhaust/Fresh air louvers of 80 mm thick high performance (55% free area) drainable fixed louver type powder coated Aluminium frame and blades. Mullions to be sliding interlock type with integral internal drain. Jamb and mullion drains to be open on front face in order to direct water away from inside of louver. Blades to be one piece extrusions with gutters design to catch and direct water to jamb and mullion drains. Fasteners to be aluminium. Louvers to have framed 13 mm mesh removable mill finish aluminium bird screens.

13. FLEXIBLE DUCTING

Insulated flexible duct should be IS/UL 181 CLASS I AIR DUCT LISTED AND LABELLED WITH NFPA 90A & 90B AND SEAL OF AIR DIFFUSION COUNCIL with double lamination of tough polyester which encapsulates steel helix wire forms the air tight inner core, double layer core wrapped in a multiple thickness of fiberglass wool with R Value 4.2, Green guard certification of fiberglass wool must. Reinforced and sheathed in a rugged and durable tridirectionally reinforced metalized polyester jacket. Flexible duct connections should be made as per IS/UL181 listing procedure with proper flexible right forming brace connection allowing right connections for flexible duct into energy efficient. and Strapping the flexible duct connections with flexible duct strap ties.

14. BALANCING

Air systems shall be balanced in a manner to minimize throttling losses. The entire air distribution system shall be balanced with the help of an anemometer.

The measured air quantities at fan discharge and at the various outlets shall be within ± 5 percent of those specified/quoted. For fans greater than 0.75 KW (1.0 HP), fans must then be adjusted to meet design flow conditions. Branch duct adjustments shall be permanently marked after the air balancing is completed so that these can be restored to their correct position if disturbed at any time.

15. Flexible Canvass Connections (For Fans, AHUs etc.)

Flexible canvass connections to isolate vibrations produced by Air handling units, Axial Flow fans and other air moving equipments when these are to be connected to air ducts where ever specified. Canvass connections shall be of the same cross-sectional area as the mating fan inlet/outlet or duct section.

Flexible canvass connection shall be provided with 45 mm galvanized metal strip of minimum 0.40 mm thickness both side with minimum 0.80 mm this fabric for easy connection to duct or equipments. The fabric shall be fire resistant, fiberglass weave with silicone rubber coating on both side. Flexible connector fabric shall withstand severe effects of strong sunlight, weathering and ageing. Flexible duct connector fabric shall be air tight, waterproof, virtually chemically inert and shall not emit toxic fumes when exposed to open flame. The flexible canvass connection shall be suitable to withstand the positive and negative fan pressures at point of installation to which they will be subjected to and shall not allow perceptible leakage and shall be completely free from stress and shall not be required to accept any weight.

Duct work connections to the fan inlets / outlets shall be concentricity aligned so that the flexible connections are not subjected to any strain

Flexible Duct connector shall be tested and certified in accordance with BS 476 part 7 for class 1 and NFPA -701 from NABL accredited lab

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6.18 DUCT SUPPORTING SYSTEM

Wire Hangers shall be used to suspend all static HVAC Air Distribution services.

Wire Hangers should consist of a pre-formed wire rope sling with a range of end fixings to fit various substrates and service fixings, these include a ferruled loop, permanently fixed threaded M6 (or M8, M10, M12) stud/eyebolt, permanently fixed nipple end with toggle, at one end or hook or eyelet, cladding hook, barrel, wedge anchor, eyebolt anchor or any other end fixture type or size as per manufacturers recommendation and design. The end fixings and the wire must be of the same manufacturer with several options available. The system should be secured and tensioned with a Hanger self-locking grip (double channel wedge type lock) at the other end. Once the grip is locked for safety purpose unlocking should only be done by using a separate setting key and should not be an integral part of the self-locking grip. Only wire and/or supports supplied and/or approved, shall be used with the system.

- a. Wire Hangers should have been independently tested by Lloyds Register. APAVE, TUV, CSA, Chiltern International fire, ADCAS, Intertek, ECA, and SMACNA, approved by CSA and comply with the requirements of DW/144 and BSRIA – wire Rope Suspension systems. Wire rope should be manufactured to BSEN 12385: 2002
- b. Wire Hangers shall be independently tested by reputed third party testing organization to sustain safe working load for 120min at elevated temperature of 175 deg. C or above.
- c. The contractor shall select the correct specification of wire hanger to use for supporting each particular service from table 1 below. Each size is designated with a maximum safe working load limit (which incorporates a 5:1 safety factor).

The correct specification of wire hanger required is determined using the following formula.

Weight per meter of object suspended (kg) X distance between suspension points (m) = weight loading per Hanger suspension point (kg).

Where the installed wire rope is not vertical then the working load limit shall be reduced in accordance with the recommendations give in the manufacturer's handbook.

The contractor shall select the correct length of wire rope required to support the service. Lengths from 1-10m lengths. Specials can be made, check with manufacturer. No in-line joints should be made in the rope.

Table. 1

Size	Working Load Limit (kg/lbs)
No. 1	0-10 kg/0-22 lbs

No. 2	10-45 kg / 23-100 lbs
No. 3	45-90 kg/101-200 lbs
No. 4	90-225 kg / 210-495 lbs
No. 5	225-325 kg/ 496-715 lbs
No. 6	325-500 kg/ 715-1100 lbs

The standard range of Hanger Kits should contain galvanized high tensile steel wire rope or stainless steel wire rope as per the application, the minimum specification is as above and should be manufactured to BS 302 (1987), BSEN12385. **Comply with manufacturer's load ratings and recommended installation procedures.** The testing shall be done to the minimum breaking load of the wire thus giving a minimum safety factor of 5: 1.

HVAC Supports –Hanger Supports are suitable for: Rectangular duct, Spiral Duct, Oval Duct, Fabric Duct

Ducting Supports:

All ductwork shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with hangers formed of galvanized steel wire ropes and galvanized steel angle/channel or a pair of brackets, connected by galvanized steel wire hangers under ducts, rigid supports may be provided at certain interval if need be. The spacing between supports should be not greater than 2.4 meter. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates or Toggle end wire fixing left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the wire rope hanger shall be welded to the plates. Trapeze hanger formed of galvanized steel wire rope using lock shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash/anchor fastener driven into the concrete slab by electrically operated gun. Wire rope supports shall hang through the cleats or wire rope threaded studs can be screwed into the anchor fasteners. In case of PEB structure Loop and Catenary system can be used based on the site conditions as per approved suspension system drawings.

All horizontal ducts shall be adequately secured and supported. In an approved manner, with trapeze Hangers formed of galvanized steel wire rope in a cradle support method (refer to typical drawings) under ducts at no greater than 3000mm centre, for 3001mm-above appropriate size angle along with neoprene pad in between the duct & MS angle should be used with prior approval. All vertical duct work shall be supported by structural members on each floor slab. Duct support shall be through dash / anchor fastener driven into the concrete slab by electrically operated gun. Hanger wires shall then hang around the ducting. Rigid supports shall be used in conjunction with wire rope hangers to assist with alignment of services where recommended for by the manufacturer. Rigid support must also be used in conjunction with wire rope hangers with duct work as per support GFC/design drawings. Support ducting in accordance with Schedule I at the end of this Section. Any other wire rope solution in compliance

to specifications can be used, based on manufacturer's recommendation as per site conditions, after prior approval. In cases of Spiral ducting the wire can be wrapped directly around the ducting without the need for a spiral ducting clamp for sizes above 1100 a cradle support should be provided, refer to manufacturer's recommendations.

Ducting over furred ceiling shall be supported from the slab above or from beams after obtaining approval of Construction manager/consultant. In no case shall any duct be supported from false ceiling Hangers or be permitted to rest on false ceiling. All metal work in dead or furred down spaces shall be erected in time to occasion no delay to other Contractor's work in the building. All supports of pipe shall be taken from structural slab/wall by means of fastener.

Catenary Supports: Refer to manufacturer's recommendations on Catenary supports with C-clip, special care should be taken with tensioning of the wire and angles at which the installation of services are made.

Stainless Steel Supports should be available for food, chemical and High Corrosion areas near coastlines.

Refer to manufacturers catalogue and installation guide for further technical information. **Comply with manufacturer's load ratings and recommended installation procedures.**

Duct Installations (As per NBC 2016 (Part – 8.3) Clause-12.1.7.1)

Schedule I: Duct Hanger Schedule

For ducts with external SP upto 250 Pa			For ducts with external SP upto 500 Pa		
Maximum Duct Size (mm)	Gauge	Hanger No.	Maximum Duct Size (mm)	Gauge	Hanger No.
1 - 750	26	1 or 2	1-600 mm	26	1 or 2
751-1000	26	2	601-750 mm	26	2
1001-1200	24	2 or 3	751-1000 mm	24	2 or 3
1201 - 1500	24	3	1001-1200 mm	22	3 or 4
1501 - 1800	22	3 or 4	1201-1300 mm	20	3 or 4
1801-2100	20	3 or 4	1301-1500 mm	18	4
2101-2700	18	4	1501-1800 mm	18	4
			1801-2100 mm	18	4
			2101-2250 mm	18	4 or 5
			2251-2400 mm	18	4 or 5
			2401-2700 mm	18	4 or 5

Notes: All supports are considered at 2400 mm interval in above table and may vary as per the design but should not be greater than 2400mm.

Desertification fans, Air Conditioning Units, Plenum Boxes, Radiant Panels, Heaters, Fan Coil Units, Diffusers, Cassette units and Chilled Beams.

All units shall be adequately secured and supported in an approved manner using wire hanger suspension Y fit solution as per manufacturers' recommendation with prior approval.

Rigid Supports:

Rigid supports if required in conjunction with wire hangers shall be of steel, adjustable for height and Zinc chromate primer coated and finish coated black, Galvanized Strut support system of required strength and profile can also be used. Where supports and clamps are of dissimilar materials, a gasket shall be provided in between. If the MS angle at the bottom if required as per design should be as per following table:

Longer size of Duct	Type of Joints
Up to 750	25x25x3 mm L angle with M8 nuts & bolts
751-1000	25x25x3 mm L angle with M8 nuts & bolts
1001-1500	40x40x5 mm L angle with M8 nuts & bolts
1501-2250	50x50x5 mm L angle with M10 nuts & bolts
2251 & above	50x50x6 mm L angle with M10 nuts & bolts

All the supporting system should be supplied from same manufacturer.

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6.19 DEMAND CONTROL VENTILATION

1.0 VAQ Station – General

All the VAQ (Variable Air Quality) Station shall be Pressure Independent type with Direct Digital Controls to regulate and monitor the primary air flow rate between the scheduled minimum and maximum values to achieve the specified comfort level and ventilation rates within acceptable noise criteria. A separation shall be made in VAQ Station-SA (Standard VAV Terminals), and VAQ Station-OA (for non ducted application) as detailed in the schedule.

The VAQ Station shall controls air to provide desired zone temperature, and required minimum volume of outdoor air for proper ventilation as per ASHRAE Standard 62. The controller shall measures the pressure, position of the damper blades, and temperature of the air flowing through the damper.

The VAQ Station shall have an air measuring station with an ultra-lowleak, high performance control damper similar to AMCA Class-I leakage. The complete assembly shall be factory assembled and tested to provide effective set point monitoring and adjustment. The unit shall come standard with a pressure transducer, with the output signal proportional to cfm and factory fitted standalone DDC controller.

1.1 Overview of VAQ Station-Outdoor Air (For non-ducted application)

In this application, an air measuring control damper shall provides Outdoor, Return and Exhaust air control based on a demand signal. The demand signal shall be determined by a set schedule or by occupancy sensors. Examples of demand signals are carbon dioxide (CO₂) concentration, a binary signal from a motion detector, or a manual switch.

1.2 Construction

The casing shall be single skin made out of galvanized sheet steel with acoustic lining from inside. Casing leakage rate shall be Similar to AMCA class I leakage. All VAQ Station shall have rectangular duct connection with 25 mm. flange connections at the outlet of the station.

The VAQ Station shall have a air-flow straightener of 3” deep hexagonal pattern at the inlet of the station to provide necessary laminar air flow suitable for measurement, and a multi-leaf opposed blade damper with aluminum, aerofoil blade construction, width 100 mm., and exposed gear driven. The damper spindle shall be made of steel (10 mm. diameter), rotating in self lubricating Nylon bearings.

Each VAQ Station, shall be factory fitted with a multipoint, averaging air flow sensor in the inlet of the terminal. This air flow sensor shall amplify the air

pressure signal linearly with an amplification factor of at least 3.0. The air flow sensor shall contain not less than 2x8 sensing points, which shall be arranged as per LOG-TCHEBYCHEFF rule. The signal shall be averaged and measured from the center of the sensor. And the accuracy shall be within 5% even with irregular duct approach.

1.3 Control

1.3.1 Controller

Controller shall be DDC Advanced Application Controller that communicates on direct digital control using point 2 point analog controls and compatible with existing or future BMS system.

1.3.2 Actuator

Actuator shall have a pressure sensor, digital VAV controller and damper actuator all in one, providing a Compact solution with a communications capability for Pressure-independent VAV and CAV systems in the comfort zone.

It should also have a connection facility for commissioning Diagnostic socket for operating devices.

1.3.3 CO₂ Sensor

CO₂ sensor shall have voltage proportional signal i.e.0-10 vdc & should be capable of measuring 0-2000 ppm of CO₂ Concentration with a resolution of maximum 50 ppm.

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6.20 PIPING

1. SCOPE

The scope of this section comprises the supply and laying of pipes, pipe fittings and valves, testing and balancing of all water and refrigerant piping required for the complete installation as shown on the Drawings. All piping inclusive of fittings and valves shall follow the applicable Indian Standards

2. Pipe Sizes

Pipe sizes shall be as required for the individual fluid flows. Various pipe sizes shall be as per design, these are for Contractor's guidance only and shall not relieve contractor of responsibility for providing smooth noiseless balanced circulation of fluids.

3. CHILLED AND CONDENSER WATER PIPING

- The pipe shall be MS ERW as specified in the Piping Section.
- The pipes size 150 mm and below shall be M.S. 'C' class as per IS : 1239 and pipes size above 150 mm shall be welded black steel pipe heavy class as per IS : 3589 from minimum 6.35 mm thick M.S. sheet for pipes up to 350 mm dia and for minimum 7 mm thick M.S. sheet for pipes for 400 mm dia and above.
- For detail of insulation, refer Insulation section.

Grooved Couplings & Fittings shall be used to join pipes from 20 NB & Above. No Welding is allowed.

Pipe/Grooved: Carbon Steel / MS- Roll grooved-ends as appropriate to pipe material, wall thickness, pressures, size and method of joining. The Grooving Machine used shall be of the same manufacturer as Grooved Couplings & Fittings. Groove Measuring Tape shall be used to check the Groove in the pipe.

Standard Mechanical Couplings, 2 inch (DN50) through 12 inch (DN300): Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. (Gaskets used for potable water applications shall be UL classified in accordance with ANSI/NSF-61 for potable water service.) Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A- 183, minimum tensile strength 110,000 psi (758450 kPa).

Grooved Couplings requiring Torque to tighten as a part of their installation shall not be allowed till 12”.

Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1, B31.9, and NFPA 13.

a. 2" (DN50) through 8" (DN200): Installation ready rigid coupling Style 107 for direct stab installation without field disassembly. Gasket shall be Grade "EHP" EPDM compound with red color code designed for operating temperatures from -30 deg F (-34 deg C) to +250 deg F (+120 deg C)

b. 10" (DN250) through 12" (DN300): Standard rigid coupling Style 07- Gasket shall be Grade "E" EPDM compound with green color code designed for operating temperatures from -30 deg F (-34 deg C) to +230 deg F (+110 deg C)

Flexible Type: Use in locations where vibration attenuation and stress relief are required. Flexible couplings may be used in lieu of flexible connectors at equipment connections. Three couplings, for each connector, shall be placed in close proximity to the vibration source.

a. 2" (DN50) through 8" (DN200): Installation ready flexible coupling for direct stab installation without field disassembly. Gasket shall be Grade "EHP" EPDM compound with red color code designed for operating temperatures from -30 deg F (-34 deg C) to +250 deg F (+120 deg C) -

b. 10" (DN250) through 12" (DN300): Gasket shall be Grade "E" EPDM compound with green color code designed for operating temperatures from 30 deg F (-34 deg C) to +230 deg F (+110 deg C)

2. Flange Adapters: For use with grooved end pipe and fittings, flat faced, for mating to ANSI Class 125/ 150 flanges/ PN 10/ PN 16

3. Grooved couplings shall meet the requirements of ASTM F-1476.

4. Gasket: Synthetic rubber conforming to steel pipe outside diameter and coupling housing, manufactured of elastomers as designated in ASTM D- 2000.

Grooved AGS Mechanical Couplings - 14 inch (DN350) & above: Couplings shall consist of two ASTM A-536 ductile iron housing segments, a wide elastomer pressure responsive gasket, and zinc electroplated carbon steel track head bolts and nuts conforming to the physical and chemical requirements of ASTM A-449 and the physical requirements of ASTM A-183.

a. Coupling housings designed with the wedge-shaped AGS key profile to engage the mating pipe(s)/component(s) wedge-shaped AGS grooves. Housings include lead-in chamfer to accommodate a wide range of initial pipe positions. Housings shall be coated with orange enamel

Grooved End Fittings:

Standard fittings shall be cast of ductile iron conforming to ASTM A-536, Grade 65-45-12, forged steel conforming to ASTM A-234, Grade WPB 0.375" wall (9,53 mm wall), or fabricated from Std. Wt. Carbon Steel pipe conforming to ASTM A-53, Type F, E or S, Grade B. Fittings provided with an alkyd enamel finish. Zinc electroplated fittings and couplings conform to ASTM B633.

AGS Fittings shall be supplied with factory AGS grooved ends. Fittings shall be manufactured of ductile iron conforming to ASTM A-536, forged carbon steel conforming to ASTM A-234, or factory fabricated from carbon steel pipe conforming to ASTM A-53. Fittings shall be manufactured to the dimensional standards ASME B16.9. Orange enamel coated - for use with Grooved AGS Product

Hole-Cut Branch Outlets:

Bolted Branch Outlet: Branch reductions on 2"(DN50) through 8"(DN200) header piping. Bolted branch outlets shall be manufactured from ductile iron conforming to ASTM A-536, Grade 65-45-12, with synthetic rubber gasket, and heat treated carbon steel zinc plated bolts and nuts conforming to physical properties of ASTM A-183

All grooved components shall conform to local code approval and/or as listed by ANSI-B-31.1, B-31.3, B-31.9, ASME, UL/ULC, FM, IAPMO or BOCA.

Installation Ready Couplings shall be installed directly in the pipe without disassembling the Gasket.

Grooved end product manufacturer to be ISO-9001 certified.

Ball and butterfly valves conforming to the following specifications shall be provided as shown on Drawings :

Size	Construction	Ends	Type
15 to 32 mm	Brass ASTM B62	Screwed	Ball
40 mm and over	Body Cast iron,	Wafer	Butterfly

Type and requirements shall be as per design. Valves shall be non-rising spindles unless specified otherwise and shall be suitable for PN 16 rating.

Butterfly valves shall perform the function of isolating valves. Butterfly valves shall have Aluminium / Ductile Iron body with EPDM seal & SS 316 Disc and shall be suitable for PN16 rating. All butterfly valves shall be provided with locking devices. Valves 250 mm and above dia shall be gear driven.

Balancing Valves shall be of cast iron flanged construction with EPDM/SG iron, with epoxy coated, with built in pressure drop measuring facility (pressure test cocks) to compute flow rate across the valve. The test cocks shall be long enough to protrude out of pipe insulation

Automatic balancing valves shall automatically control flow rates with + 5% accuracy. Valve control mechanism shall consist of a stainless steel cartridge with a ported cup and coil/helical spring to avoid corrosion. Four operating ranges shall be available. Manufacturer shall provide independent laboratory tests verifying assurance of performance.

Manual double regulating balancing valves shall be provided at chiller, condenser, various tap-offs and each AHU outlet line as per design. These valves shall have built-in pressure-drop measuring facility to compute flow rate across

the valve. The test cocks shall be long enough to protrude out of pipe insulation. To enable accurate and practical operation, measurement of flow and differential pressure shall be made with a computerized balancing instrument which shall enable the operator to read the flow directly without the use of diagrams or tables. In addition to measuring flow rate, differential pressure and temperature, computerized balancing instrument shall have a computer programme to provide the following functions:

- To balance the HVAC installation and calculate the necessary valve settings, based on system measurements.
- To store the results of balancing.
- To log measured values from a valve (differential pressure, flow rate or temperature).
- To printout saved data in computerized measurement protocol(CMP) consisting of:
 - Name and size of Balancing Valve (BV)
 - Presetting position of BV
 - Pat BV
 - Flow at BV
 - Design Flow

Flanges shall be of approved make. The supply of flanges shall form part of piping (not separately identified) and shall also include supply of bolts, washers, nuts and suitable asbestos fibre/ rubber insertion gaskets (minimum 3 mm thick).

All ball valves and ball valves with Y strainer of 32 mm diameter and below shall be bronze forged body construction with chrome plated bronze ball and handle of stainless steel constructions. These are separately identified.

Non-return valves shall be dual plate check valve provided as identified in conforming to relevant Codes and in accordance with the following Specifications:

chrome overlay.

Size	Construction	Ends	Type
50 to 150 mm	Body cast iron	gun metal plate.	Flanged
200 mm to 450 mm	Body Cast iron,	plate carbon steel with 11%	Flanged chrome overlay

The spring and hinge/stop pin shall be SS304 and bearing PTFE material. Valves shall be PN 16 rating.

Valve Description

	For 15 to 40 mm	For 50 to 150 mm
Static Pressure	2500 kPa, 360 psi	4000 kpa, 580 psi

Media Temperature	-20° to 120° C, -4° to 248° F	-20° to 120° C, -4° to 248° F
Ambient Temperature	10° to 54° C, 14° to 131° F	10° to 54° C, 14° to 131° F
Body material	Forged Brass-IS/ ASTM B584	Ductile Iron, IS/ ASTM A536-65T, Class 60-45-18
Internal Components	IS/ AISI Type 316 Stainless Steel	IS/ AISI Type 316 Stainless Steel
Test Ports /Body Tapings	¼" NPT (Body Tapings)	¼" ISO (Test Ports)
End Connections	Bronze Alloy ISO, NPT or Sweat	Wafer style (by others)
Stem Seals	EPDM and Nitrile O-Rings	EPDM
Maximum Close Off Pressure	700 kPaD, 101 psi	700 kPaD, 101 psi
Maximum Operational	320 kPaD, 46 psi	400 aD, 58 psid

4. TWO WAY MOTORIZED BUTTERFLY VALVE

4.1 Valve

a)	Type of valve	:	Butterfly Valve.
b)	Body Material	:	Carbon steel IS/ ASTM A 216
c)	Body seat ring (if applicable)	:	Gr WCB
d)	Vane	:	SS-316/416
e)	Packing	:	Teflon
f)	Mounting Stool	:	Required.
g)	Shaft	:	SS-316
h)	Seat	:	Nitrile rubber
i)	Fasteners	:	SS-316
4.2 Actuators			
	Type	:	Electric
	Duty.	:	On/Off
	Motor power supply	:	230 V AC or 415 V 3-phase
	Hand wheel	:	Required
	Speed	:	As per manufacturer standard

NOTE:-

- a) Actuator must open/ close with one changeover contact. Control panel, if required, must be supplied integral with the Actuator.

- b) No gear box is envisaged, however if gear box is provided, the travel limit switches must be connected directly to the valve stem.
- c) Cover tube for the valve stem must be provided

5. 2 WAY MODULATING/ PRESSURE INDEPENDENT BALANCING AND CONTROL VALVE:

5.1 HVAC APPLICATION - COOLING – AHU's.

A pressure independent balancing and control valve shall be a self balancing, pressure independent, 2-way control valve with 100% authority on the control valve.

It can be fitted with an actuator to accept input signals from the control system.

Each Air Handling Unit shall be provided with a 2-way Pressure Independent Balancing and Control Valve. The control valve should be a globe/ ball type.

Regarding control - The response characteristic should be independent of pressure.

A differential pressure controller should ensure 100% valve authority at all loads and all settings.

Regarding Balancing - Each Valve should have a precisely adjustable maximum flow limitation as per the designed flow rate of coils. The balancing should be done only in the valve and not in the actuator so that in case of actuator failure, the balancing is not lost and the system can still function as designed.

All Valves actuators should be microprocessor based with a self-calibrating feature to adjust to any valve travel or setting with full control range.

The valve should have a linear characteristic and the actuator should have a function that can convert it to a logarithmic characteristic to ensure that the valve actuator combination can be used for all applications.

Minimum required differential pressure should not exceed 20 kPa for fan coil units DN32 and not exceed 30 kPa for air handling units to minimize pump head requirements.

The valve should be equipped with an electronic modulating actuator. The actuator shall be capable of accepting upto 10V DC and upto 20mA electric signal. Operating voltage for actuator shall be 24 V DC to close against maximum differential pressure of 6 Bar.

5.2 ACTUATOR SPECIFICATIONS FOR ALL SIZES :

Supply Voltage	:	24V AC Power
Consumption	:	2 V AC,
Frequency	:	50 HZ
Control Input	:	2-10V DC, 4-20mA, 3-point Selection.
Position Output	:	2-10V DC, 4-20mA,
Body Housing Insulation	:	Non Corrosive - IP 42 or higher

GENERAL SPECIFICATIONS:

Pressure Independent Balancing and Control Valve shall be provided/installed at each outlet of cooling coil unit, AHU.

5.3 Valve Body and Characteristics:-

- The differential pressure controller should maintain a constant differential pressure across the control valve, irrespective of fluctuations in the system, with the help of a self-adjusting diaphragm.
- The control valve shall accurately control the flow with help of a modulating actuator.
- All valve sizes should have testing ports for verifying the flow by measuring the differential pressure.

5.4 Valve Actuator and Housing:-

- The valve and actuator must have the ability to undertake both Logarithmic control characteristics and linear control characteristics. This ensures compatibility for both Water/Air and Water/Water Heat Exchanger.
- Control/Dip switch settings should be easy to access, to avoid Manual Contact directly with Integrated IC Circuit of the system.
- The actuator should not play a part in the balancing process. This will ensure that an operational issue in the actuator will not lead to a loss of balancing, causing problems elsewhere in the system.
- Only linear characteristics should not be acceptable as with this valve & actuator characteristic, the resultant energy characteristic will not remain linear and this shall lead to improper control leading to fluctuating room temperatures.
- In chilled water systems, the valve should be mounted with the actuator above the valve to prevent condensation water leaking into the actuator.

6.0 THERMOSTATS:

Shall be cooling electronic type with 3-point output for modulating 2 position reversible motor of two-way valve of AHU/FCU/Cassette with sensing element located in the return air stream. The profile, mounting arrangements and exact location of the thermostats shall be as approved by the Engineer in charge in consultation with AAI. All thermostats shall be supplied with the standard mounting boxes, as recommended by the manufacturer.

Electronic type thermostats for cooling application for actuating the two way modulating cum pressure independent balancing valve at each unit.

7.0 COLD WATER AND DRAIN PIPING

- a) All pipes to be used for cold water (makeup), drain, condensate drain and fittings shall be GI/ U PVC.
- b) All jointing in the pipe system shall be by screwed joints and/or by screwed flanges using 3 mm 3 ply rubber insertion gaskets. Pipe threads and flanges shall be as per relevant BIS Codes.
- c) All pipes support shall be mild steel, thoroughly cleaned and given one primary coat of red oxide paint before being installed.
- d) Fittings shall be galvanized steel 'medium class' malleable casting of pressure rating suitable for the piping system. Supply of flanges shall include bolts, nuts, gaskets as required. Sufficient number of flanges and unions shall be provided for future cleaning and servicing of piping. Tee-off connection shall be through equal or reducing tees. All equipment and valve connections, or connections to any other mating pipes shall be through flanges required for the mating connections. Fittings & flanges shall form part of piping as per system requirement.
- e) Gate valves, globe valves, check valves and strainers shall be similar to those specified for chilled, condensing and piping.
- f) For proper drainage of AHU Condensate, 'U' trap shall be provided in the draining piping.
- g) All condensate drain piping shall be insulated and painted as per the section "Insulation" and approved by Engineer in Charge.

8.0 REFRIGERANT PIPING

- a) All refrigerant pipes and fittings shall be hard drawn copper tubes and wrought copper/ brass fittings suitable for connection with silver solder / phos-copper.
- b) All joints in copper piping shall be sweat joints using low temperature brazing and/ or silver solder. Before jointing any copper pipe or fittings, its interiors shall be thoroughly cleaned by passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean of dirt etc. while constructing the joints. Subsequently, it shall be thoroughly blown out using carbon dioxide/ nitrogen.
- c) Refrigerant lines shall be sized to limit pressure drop between the evaporator and condensing unit to less than 0.2 kg per sq.cm.
- d) Sight glass with moisture indicator and removable type combination dryer cum filter with MS housing and brass wire mesh/ punched brass sheet shall be installed in liquid line of the refrigeration system incorporating a three valve by pass. After ninety days of operation, liquid line drier cartridges shall be replaced.
- e) Heat exchanger shall be MS heavy duty pipe in pipe type and without any joint in the inner pipe.

- f) Horizontal suction line shall be pitched towards the compressor and no reducers shall be provided for proper oil return.
- g) After the refrigerant piping installation has been completed, the refrigerant piping system shall be pressure tested using Freon mixed with nitrogen at a pressure of 20 kg per sq. cm (high side) and 10 kg per sq. cm (low side). Pressure shall be maintained on the system for a minimum of 12 hours. The system shall then be evacuated to a minimum vacuum of 70 cm of mercury and held for 24 hours. Vacuum shall be checked with a vacuum gage.
- h) All refrigeration piping shall be installed strictly as per the instructions and recommendations of air conditioning equipment manufacturer.

9.0 PIPING INSTALLATION

- a) Design Drawings indicate schematically the size and location of pipes. The EPC CONTRACTOR, on award of the work, shall prepare detailed shop drawings, showing the cross-section, longitudinal sections, details of fittings, locations of isolating and control valves, drain and air valves, and all pipe supports. He must keep in view the specific openings in the building through which pipes are designed to pass.

Pipe shall be cut only with hack saw blades and welding rods shall not be used for this purpose. All the pipes shall be cleaned and applied with one coat of Zinc chromate primer.

- b) Piping supports shall be adjustable for height and primer coated with rust preventive paint and finish coated with gray paint, both as approved by department spacing of pipe supports shall as per **NBC 2016**; (Part-8.3) – **12.1.8** & Table – 13.

All pipes in HVAC plant room shall be supported with pipes and channels from floor only with necessary PUF pipe supports and resistoflex sheet.

- c) Pipe supports shall be of steel, adjustable for height and Zinc chromate primer coated and finish coated black. Where pipe and clamps are of dissimilar materials, a gasket shall be provided in between.

Pipe size	Spacing between supports	Rod Size
Upto 12 mm	1.5 Meter	10 mm
15 to 25 mm	2.0 meter	10 mm
32 to 150 mm	2.0 meter	10 mm
Over 150 mm	2.5 meter	12.5 mm

- d) Vertical pipes passing through floors shall be plumb and parallel to wall. Pipes shall be supported on alternate floor. MS cleats shall be welded on pipes and rest on MS channel placed on the floor with 15 mm thick resistoflex pads between the cleat and channel. U clamps with resistoflex sheet shall be provided to keep the pipe in position.

- e) Bull heading in water/refrigerant piping shall be avoided.
- f) Pipe sleeves atleast 3 mm thick, 50 mm/ 100 mm larger in diameter than condenser/chilled water pipes respectively shall be provided wherever pipes pass through retaining wall and slab. Annular space shall be filled with fiberglass and finished with retainer rings welded on the ends of the sleeve.
- g) Wherever pipes pass through the brick or masonry/ slab openings, the gaps shall be sealed with fire sealant such as fire barrier caulks.
- h) Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation. 20 gauge metal sheets shall be provided between the insulation and the clamp, saddle or roller, extending atleast 15 cm on both sides of the clamp, saddles or roller.
- i) All piping work shall be carried out in workmen like manner, causing minimum disturbance to the existing services, buildings and structure. The entire piping work shall be organized, in consultation with other agencies work, so that laying of pipes, supports, and pressure testing for each area shall be carried out in one stretch.
- j) Cut-outs in the floor slabs for installing the various pipes are indicated in the Drawings. EPC CONTRACTOR shall carefully examine the cut-outs provided and clearly point out where the cut-outs shown in the Drawings do not meet with the requirements.
- k) The EPC CONTRACTOR shall make sure that the clamps, brackets, clamp saddles and hangers provided for pipe supports are adequate. Piping layout shall take due care for expansion and contraction in pipes and include expansion joints where required.
- l) All pipes shall be accurately cut to the required size in accordance with relevant BIS Codes, edges bevelled and burrs removed before laying. Open ends of the piping shall be closed as the pipe is installed to avoid entrance of foreign matter. Where reducers are to be made in horizontal runs, eccentric reducers shall be used for the piping to drain freely. In other locations, concentric reducers may be used.
- m) Flanged inspection pieces 1.5 meters long, with bolted flanges on both ends, shall be provided no more than 30 meters centres, or where ever shown in Approved for Construction shop drawings, to facilitate future cleaning of all welded pipes.
- n) All buried pipes shall be cleaned and coated with zinc chromate primer and bitumen paint, and placed on concrete blocks with PUF saddles dipped in bitumen at every 2 meters and wrapped with three layers of fibre glass tissue, each layer laid in bitumen.
- o) Insulated buried pipes shall be cleaned, de rusted, then coated with rust resistant primer and placed on concrete blocks with PUF saddles dipped in bitumen at every 2 meters. Insulation shall be applied as per the section "insulation", wrapped with GI wire and covered with polyethylene sheet. Two coats (each 6 mm thick) of cement plaster shall be applied over chicken wire mesh lath. Where indicated in, buried insulated pipes shall be water

proofed using coat of Shalibond, or approved adhesive, over the plastered surface; wrapping one layer of fibre glass RP tissue and one layer of roofing tarfelt with sufficient overlaps, set and sealed with the adhesive, held in position by 16 gauge G.I wire tied at 15 cm intervals.

p) Auto purge valves shall be provided at all highest points in the piping system for venting air. Air valves shall be 15 mm pipe size with screwed joints.

q) Discharge from the air valves shall be piped through an equal sized mild steel or galvanized steel pipe to the nearest drain or sump. These pipes shall be pitched towards drain points.

10.0 Testing

During construction, the EPC Contractor shall properly cap all lines, so as to prevent the entrance of sand, dirt, etc. Each system of piping shall be flushed thoroughly after completion (for the purpose of removing dirt, grit, sand etc. from the piping and fittings) for as long a time as is required to thoroughly clean the system.

a) All piping shall be tested to hydrostatic test pressure of at least two times the maximum operating pressure, but not less than 10 kg per sq. cm gage for a period of not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified, retested and gotten approved.

b) Piping repaired subsequent to the above pressure test shall be re-tested in the same manner.

c) Piping may be tested in sections and such sections shall be securely capped, then re-tested for the entire system.

d) The EPC Contractor shall give sufficient notice to all other agencies at site, of his intention to test a section or sections of piping and all testing shall be witnessed and recorded by Engineer-In-Charge.

e) The EPC Contractor shall provide temporary pipe connections to initially by-pass condenser/ chiller and circulate water through condenser/ chilled water pipe lines for minimum 8 hours. Water should be drained out from the lowest point. The temporary lines shall be removed and blanked with dead flanges. Pot strainers and Y strainers shall be cleaned and fresh water filled in the circuits.

f) After regular flushing, as per 'f' above, all systems shall be chemically cleaned. Chemical cleaning shall be carried out in 3 stages. In first stage biological cleaning shall be done to remove algae, bacteria, SRB etc. which produces slimes. Second stage in pre-cleaning in which loose rust, oil, and debris are removed. Chemical addition and hold up time shall be as per chemical supply agencies recommendations. Third stage is passivation, in which chemicals will be added and passivation film will be formed over inside surfaces of piping system. Type of chemical used and quantity of the same along with detailed method statement shall be submitted by EPC CONTRACTOR for Engineer-In-Charge approval before starting this activity.

Before handover Engineer-In-Charge shall be provided with certificate of cleaning of pipe systems, signed by the EPC CONTRACTOR.

g) After the piping has been installed, tested and run for atleast three days of eight hours each, all insulated exposed piping in plant room shall be given two finish coats, 3 mils each of approved colour, conforming to relevant BIS Codes.

h) The direction of flow of fluid in the pipes shall be visibly marked with identifying arrows. For painting of insulated and clad pipes refer to Insulation section.

i) The EPC Contractor shall make sure that proper noiseless circulation of fluid is achieved through all coils and other heat exchange equipment in the system concerned. If proper circulation is not achieved due to air bound connection, the EPC Contractor shall rectify the defective connections. He shall bear all expenses for carrying out the above rectifications including the tearing up and re-finishing of floors and walls if required.

j) The EPC CONTRACTOR shall provide all materials, tools, equipment, instruments, services and labour required to perform the test and to remove water resulting from cleaning and after testing.

11.0 Balancing

a) After completion of the installation, all water system shall be adjusted and balanced to deliver the water quantities as specified, quoted, or as directed.

b) All balancing valves, Automatic control valves and two-way diverting valves shall be set for full flow condition during balancing procedure. Each water circuit shall be adjusted thru balancing valves provided for this purpose; these shall be permanently marked after balancing is completed, so that they can be restored to their correct positions, if disturbed.

c) Complete certified balancing report shall be submitted for evaluation and approval by Engineer-In-Charge. Upon approval, four copies of the balancing report shall be submitted with the as installed drawings and completion documents.

12.0 Valve Identification

Provide 30 mm dia brass valve tag, with embossed letters and number for each valve and attach the tag to valve handle by "S" hook or by suitable means. EPC CONTRACTOR shall provide valve tag schedule and valve chart for each piping system, consisting of schematic drawing of piping layout, along with a valve list, showing and identifying each valve by number, service and location and describing its function.

The EPC CONTRACTOR shall frame under glass in the airconditioning plant room or as directed by Engineer-In-Charge two copies of valve chart. Two additional unmounted copies shall be supplied to the by Engineer-In-Charge in consultation with AAI. Tags shall correspond with the valve schedule and record drawings. In

back of house areas, where ceilings are installed and the valve or valve tag is not visible, a self adhering tag with the valve number shall be installed on the wall or directly under the ceiling. For public area ceiling valves, these tags are to be installed in the service corridor, leading to the public areas.

13.0 VIBRATION ELIMINATION

Flexible coupling joints shall be provided to eliminate vibrations from moving equipment as per design and system requirement.

14.0 PAINTING

After the piping has been installed, tested and run for at least ten days of eight hours each, the piping shall be given two finish coats, 3 mils each on supply and return lines of approved colour as per instructions of Engineer-in-charge in consultation with AAI.

The direction of flow of fluid in the pipes shall be visibly marked in white arrows or as directed by the Engineer in charge in consultation with AAI.

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6.21 AIR & DIRT SEPARATOR & AUTO BACKWASH POT STRAINER

1.0 Microbubble Air/Dirt Separator

It shall work on the principle of coalescence. The shell shall be constructed of carbon steel with coalescence media of stainless steel. The water velocity inside the shell shall not exceed 1.5m/sec. The carbon steel shell to be fabricated as per IS. 2825 or other similar standard.

The inlet and outlet connections shall be flanged to IS.6392.

It shall be provided with a high capacity auto air vent at the top and a drain valve at the bottom.

Matching flanges, high tensile bolts & nuts and gasket shall be also provided by the Manufacturer.

OR

2.0 AIR & DIRT SEPARATOR

Dirt separator shall be flanged steel in-line type and shall be suitable for a maximum operating pressure of 10 Bar, unless and otherwise specified as 16 or 25 Bar in sync with system operating pressure. The dirt separator shall be suitable for maximum operating temperature of 110°C. The dirt separator shall be sized for full flow.

The entering velocities shall not exceed 1.2 MPS at a specified flow rate. Units specifically designed for high-velocity systems may have an entering velocity of up to 3.0 MPS and shall be used in case of smaller pipe size or space constraint.

The separator must conform to design as per Pressure Equipment Directive 2014/68/EU article 4 paragraph 3. The vessel shell diameter shall be of a larger cross-section than the inlet/outlet pipe diameter to reduce the flow speed in the separator. Inlet and outlet of the separator shall be accurately sized for the demand flow rate.

The core element of the separator shall be of tube mesh construction made of copper wire, and the flow to be guided through an area with a greater cross-section than the connection dimensions in order to reduce the flow speed.

Magnetic removal should be provided by insertion of Exferro high-performance magnets. The dirt separator shall be able to remove effectively dirt particles down to 5 microns. Blow-down valve shall be provided at the bottom of the unit to remove the sludge particles. Alternatively, detachable flange at the bottom shall be provided for effective cleaning. The installation of the unit should be done at a suitable height for allowing sufficient space for accessing the magnet-core easily for cleaning.

3.0 AUTOMATIC BACK WASH STRAINER

Body shall be fabricated out of M.S plate IS 226. Thickness of sheet & sizes shall be as per table below, chamfered pipe with flanges shall be provided at inlet / outlet connections of the Automatic Back Wash strainer. Butterfly valves shall be

provided at inlet / outlet connections as shown in drawing. The Automatic Back Wash strainer body shall have two separate chambers properly sealed to avoid mixing of filtered and unfiltered water. A powerful magnet shall be provided in the body to arrest MS particles.

4.0 FILTER ELEMENT

PART 1 - Outer Filter shall be made out of Stainless Steel wire mesh Gr. SS-304 having 100 mesh with wedge type Groove to have more surface area for better cleaning & shall be removed after flushing the system and before commissioning.

PART 2 - Inner Filter shall be made out of 01 mm thick non-magnetic stainless steel having 03 mm perforation (40 mesh) Gr. SS-304 properly reinforced to avoid Damage of the element.

5.0 BACK WASH SYSTEM

Automatic strainer shall have Back-wash system for cleaning the filter elements: A heavy duty Reduction Gear motor unit of stainless steel Body shall be provided at top of upper lid of Automatic Back Wash strainer. A suitable stainless steel shaft SS-304 shall be provided for rotating the backwash arrangements having Bristle Brush for cleaning in side circumference of element. Shaft shall be supported with waterproof stainless steel bearing at the bottom for better movements of rotating arrangements. All moving parts of Back Wash arrangement shall be of stainless steel SS-304. A connection of fresh water shall be provided, A spray section with Stainless steel Nozzles shall also be provided for spraying of element. Two motorized valve shall provided on fresh water connection & Drain. They shall close / Open with main starter of Drive motor when Back Wash system is in operation, all internally wired from works.

An inspection glass window 150 dia glass shall be provided at shell for checking the condition of element timely with help of a water proof light provided in the shell.

Shell of Automatic Back Wash strainer shall be painted with enamel paint of smoke grey color.

All hardware e.g. Studs, Nuts & other shall of Stainless Steel SS-304. Test Pressure ' PN 16.

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6.22 SUCTION GUIDE FOR PUMPS

Suction Guide shall be constructed of carbon steel. The flanges shall be as per IS6392-1971 standard.

The filtration media shall be stainless steel Pall rings, to slow down the flow of water and thus separate suspended impurities.

A drain plug shall be provided at the top of Suction Guide to drain out impurities lighter than water and also at the bottom to drain out impurities which are heavier than water. The bottom drain plug shall be of brass construction with SS encased high power magnet to catch magnetic debris.

Flow straightener shall be provided at the outlet of Suction Guide to ensure smooth flow of water into suction of the pump.

The Suction Guide shall be of PN 16 rating and hydraulically tested at 1.5 times of the pressure rating for one hour.

SUCTION GUIDE_FLOW STRAIGHTNER

BODY:-	MS- IS-2062.
WALL THICKNESS	50NB to 200NB - 6mm Thick. 250 & Above- 8mm Thick.

FILTER ELEMENTS

INNER FILTER-	Stainless Steel SS-304 with 3mm Perforation.
OUTER FILTER-	Stainless Steel Wire mesh with 100 mesh persquare inch. (The filter is to be removed after first flushing the System)

MAGNETIC PLUG:- A powerful magnetic plug is provided to attract the iron particles.

DRAIN:- Drain connection is provided to drain out the dirty water From the Suction guide.

SERVICING:- Suction Guides are designed in such a fashion that the filterelement can be easily assessed for Servicing without disconnecting the main pipeline.

TEST PRESSURE all suction guides are tested by Hydraulic Pressure at 21 kg/cm² before leaving works.

PAINT:- All Suction Guide are treated with anti-rust treatment, thereafter two Coates of red oxide are provided & then finally the Suction Guides are Painted with enamel paint.

WARRANTY All Suction Guided have 12 Month warranty form the dated of Purchase.

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6.23 CLOSED EXPNSION TANK WITH PRESSURIZED UNIT

1.0 Closed Expansion Tank

The closed expansion tank will be of carbon steel construction with interchangeable synthetic rubber membrane. The expansion tank shall be complete with safety relief valve and pressure gauge.

The tank will be of pressure rating to suit the system pressure and will be sized to adequately compensate for water expansion due to operating temperature variations. The tank shall be fabricated as per IS 2825-1969 for "*non-fired pressure vessels*" and the flanges shall be as per IS 6392-1971.

For chilled water application, it will be insulated with 50mm thick insulation to the specifications and cladded with 26G-aluminium cladding.

The expansion tank shall be supplied along with pressurization unit. The pressurization unit with stand by shall consist high pressure pumps of suitable pressure rating mounted on M.S. frame, complete with interconnecting piping, isolation valves, NRV, Y-strainer, pressure gauge, pressure transmitter, auto-logic panel (IP 55) with dry-run protection, electrical MCB and interconnecting wiring.

The unit shall be housed in powder-painted canopy suitable for external installation, if required.

Pressurisation Unit

Pressurisation unit with stand by shall be horizontal/vertical multistage pumps of suitable rating & capacity, as indicated hereunder, factory mounted on a steel frame along with interconnected piping, valves, strainer, pressure gauge, pressure transmitter, flow meter to measure the make-up water quantity, control panel with duty cycling and dry-run protection, electrical relays/contactors and interconnecting wiring.

Pump Capacity

PART 3 - 2 CMH, 25 mWC, PN10

PART 4 - 2 CMH, 25 mWC, PN16

PART 5 - 2 CMH, 60 mWC, PN16

PART 6 - 2 CMH, 100 mWC, PN16

PART 7 - 2 CMH, 150 mWC, PN20

The unit shall be capable of Pressurising the system to the required pressure with suction from a break-tank located at least 1m above pump level.

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6.24 THERMAL INSULATION

1.0 SCOPE

The scope of this section comprises the supply and application of insulation conforming to these specifications. The insulation material shall be Closed Cell Elastomeric Nitrile Rubber Foam Insulation.

2.0 MATERIAL

2.1 For DUCT:-

The scope of this section comprises the supply and application of insulation conforming to these Specifications.

Insulation material shall be non-toxic, chemically inert, non-combustible, non-ignitable, shall have zero ozone depletion potential, zero calorific value no heat evolution and shall be inherently proof against rotting, mould and fungal growth and attack by vermin.

The materials shall comply with following standards.

BS 476: Part 4 ' Non Combustible

BS 476: Part 5 ' Not easily Ignitable (Class P)

BS 476: Part 6 ' Fire propagation Index ($I < 12$)

BS 476: Part 7 - Surface spread of flame (Class 1)

The material should comply Class 'O' fire rating as per (BS 476 part 6&7).

The material should comply non-combustibility (BS 476 Part 4) as per National Building Code- 2016 (NBC-2016 mandates that for duct insulation non-combustible material should be used)

The product shall be able to work effectively at ambient temperature range of - 195°C to 230°C

DUCT THERMAL

MATERIAL

Insulation material of Duct shall be factory laminated FSK faced resin bonded fiberglass wool. The Thermal conductivity of the insulation material shall not exceed 0.034 W/m K at 25 deg C mean temperature. The thickness of insulation shall be so selected as to prevent any condensation and should be able to meet R-Value requirements.

The minimum thermal resistance (R-Values) for insulation of ducts (as per ASHRAE 90.12004 and ECBC 2007) shall be as described below:

Supply Air Ducts $R = 1.4 \text{ m}^2 \text{ deg. /W}$ (Thickness requirement for glass wool 50MM) Return Air Ducts $R = 0.6 \text{ m}^2 \text{ deg. /W}$ (Thickness requirement for glass wool 25MM)

The nominal density of Resin Bonded Fiberglass insulation shall be 32 kg/m³

DUCT ACOUSTIC LINING

Insulation material for Duct Acoustic Lining shall be resin bounded fiberglass wool with one side factory laminated Fiberglass Tissue. The Thermal conductivity of the fiberglass for air conditioning application shall not exceed 0.034 W/m K at 25 deg C mean temperature. The density of insulation material shall be 48 Kg./m³ and thickness of insulation material shall not less 25mm.

The installation guideline for glass wool in Duct Acoustic Lining:

1. The inside duct surface should be cleaned with suitable solvents and rendered free from all physical and chemical impurities.
2. Supply and fixing of acoustic lining of supply air duct and plenum glass wool board, with 12 mm X 25 mm GI section of 1.25 mm thick, at 600 mm center to center covered with tissue paper and 0.5 mm thick perforated aluminum sheet fixed to inside surface of ducts with cadmium plated nuts, bolts, stick pins, CPRX compound etc. complete as required and as per specifications.

2.2 AHU ROOM ACOUSTIC:-

Product: GLASSWOOL ACOUSTIC BOARD

Density: 70-80 Kg/cu.m

Thickness: 25 mm

Lamination: One Side Aluminum Foil and Other side Black Glass Cloth **Size:** 2.5 m x 1.2 m

The insulation should conform to non-combustibility, Class-P (not easily ignitable), Class 1 (surface spread of flame NIL), and Class 'O' rating as per BS 476 standards.

Installation guideline:

- 1 The surface shall be cleaned and friction fixed in 610mm X 610 mm frame of 25X25X18 mm made out of 22 G thick GI sheet U shaped channel or else it can be installed on the wall with screw bit.

- 2 If wall surface is smooth it is prefer to install acoustic board with screw bit.
- 3 The Acoustic board should be placed in such a way that black glass cloth is visible from inside the AHU /Plant room. Complete as required and as per specifications.

2.3 PIPE INSULATION: -

- 2.3.1 **Chilled water piping in basement, plant room (utility block), trench and terrace:** - Shall be insulated with 80 kg/cum density resin bonded fiber glass pipe section insulation covered with a layer of 120 gm/sqm polythene sheet (vapour barrier) and finally applying 0.63mm aluminium sheet cladding complete with type3, grade 1 roofing felt strip (as per IS:1322 as amended up to date) at joints and repairing of damage to building etc. as per specifications and as required.

Insulation thickness shall be as per following schedule: -

- a. Pipe upto 150mm-50mm thick insulation
- b. Pipe from 200mm to 400mm-75mm thick insulation
- c. Pipe above 400mm-100mm thick insulation

2.3.2 Chilled water piping in floors & risers:-

Thermal insulation material for Pipe insulation shall be Closed Cell Nitrile Rubber insulation. Thermal conductivity as per IS/ **DIN EN 12667/ EN ISO8497** of the insulation material shall not exceed 0.038 W/m²K or 0.212 BTU/ (Hr-ft²-°F/inch) at an average temperature of 30°C. Density of the nitrile rubber shall be 40-60 Kg/m³, The product shall have temperature range of -40°C to +105°C as per EN 14706, EN 14707 and EN 14304. The insulation material shall be fire rated for Class 0 as per BS 476 Part 6 : 1989 for fire propagation test and for Class 1 as per BS 476 Part 7, 1987 for surface spread of flame test. The material also pass UL 94 Test for Vertical Burning and Horizontal Burning and FM

Approved. Water vapour permeability shall be not less than 0.024 per inch (2.48 x 10⁻¹³ Kg/m.s.Pa i.e. $\mu \geq 7000$: Water vapour diffusion resistance) as per IS/ **EN 12086 & EN13469**.

For Chilled Water/ Hot Water piping insulation, nitrile rubber insulation shall be cladded with a 3-layered non-metallic composite cladding of minimum 350 micron thickness having total weight of ≥ 500 g/m², of metallic appearance with aluminum as an intermediate layer and tested for UV resistance as per EN ISO 4892-2 Method A. The Class shall be tested for Class 0 Fire performance as per BS 476 Part 7 & 6 having a flammability index ≤ 5 as per AS1530.2. The cladding material is to be applied with 30 ' 50mm overlap to be fixed with plastic rivets and finished with a silver self-adhesive tape. All bends, T- Sections and end caps shall be cladded with thermoformed fittings for pipes of upto 80mm dia.

Insulation thickness shall be as per following schedule:-

- a. Pipe upto 32mm-19mm thick insulation
- b. Pipe from 40mm to 400mm-32mm thick insulation
- c. Pipe above 400mm-50mm thick insulation

For Condensate Drain Piping, the insulation material shall be factory laminated with chemically treated glass cloth of 7mill /0.18mm thickness and tested for UV Resistance as per EN ISO 4892-2 Method A.

Insulation thickness shall be as per following schedule:-

- a. Pipe upto 50mm-9mm thick insulation
- b. Pipe from 65mm to 150mm-13mm thick insulation

The Material shall comply with BS 6853 for smoke toxicity values. The material shall comply with CFC / HCFC free material as per US EPA 5021A-2003. The material shall be Lead, mercury and asbestos free and should have zero Global Warming Potential and Ozone depleting Potential. Thermal conductivity of insulation material shall not be effected by aging as per **DIN 52616 standard**.

Insulation shall be in tube form for pipe nb dia upto 80mm and above 80mm sheets shall be used for piping.

Each lot of insulation material delivered at site shall be accompanied with manufacturer's test certificate for density and thickness. Samples of insulation material from each lot delivered at site may be selected by Owner's site representative and gotten tested for thermal conductivity and density at Contractor's cost. Adhesive used for sealing the insulation shall be rubber based contact adhesive in a blend of solvents free from benzene, non-flammable and with low VOC content (maximum 850 gm/l) strictly as per manufacturer's recommendations.

5.0 PUMP INSULATION

Chilled water pump shall be insulated to the same thickness as the pipe to which they are connected and application shall be same as above. Care shall be taken to apply insulation in a manner as to allow the dismantling of pumps without damaging the insulation.

6.0 SHELL INSULATION

The chiller shells shall be factory insulated in accordance with the manufacturer's standards.

7.0 COLD WATER AND EXPANSION TANK INSULATION

Cold water tank, and chilled water expansion tank shall be insulated as per manufacturer's standard.

- 8.0 Fire Rated Ductwork:-**Fire rated duct shall be coated with water-based fire resistance coating to provide fire rating for fully functioning ductwork system in case of fire incident to provide a sufficient time for proper evacuation to building occupants, the coating shall be free or has minimum toxic elements such as lead, mercury, arsenic and has low VOC less than 50 gm/liter as per requirement of IS/NBC/International Building Codes. Fire Resistance Coating of minimum 600'700-micron (DFT) thickness applied over ducts to provide 2 hours Fire Rating. The Fire-Resistance Coating shall be tested as per requirements of BS 476 : Part 6 'Class O' and Part 7 'Class 1' and BS 476 Part 24 (Type A and B) to analyze Stability, Integrity, and Insulation performance for 2 hours, the duct sheet shall also conform to performance criteria (stability, integrity, insulation) without insulation for 2 hours. The average and maximum temperature of unexposed faces with or without insulation shall not exceed 140 deg. Cel and 180 deg. Cel respectively to ensure the insulation performance criteria. The sealant used for Fire Rated Duct shall be water based and non-flammable type tested as per requirement of ASTM D 3278.

Kitchen Exhaust Duct:-Kitchen exhaust duct shall be painted with coating with above specification, Duct shall be wrapped with 48 Kg/m³ and 50 mm thickness of mineral wool insulation or as required to provide 2 hours rating. The adhesive shall be of non-flammable type tested as requirement of ASTM D 3278 and has VOC less than 50 g/liter.

Surface Preparation - METAL SURFACES

Galvanized Iron Ducts:-The Duct surfaces should be free from loose rust, Mild Scale and Contaminants such as oil, Grease Dirt, and Salt. Before any surface preparation is attempted, oil and grease must be removed by suitable means or any solvent cleaning. Use commercial blast cleaning in case of heavy corrosion to remove mild scale, rust, and other contaminants and leave a roughened surface.

MILD STEEL Ducts:-The Duct surface shall be rubbed with Aloxide cloth 100 to remove the carbon/rust, the Red Oxide Primer of minimum 25-micron DFT thickness shall be applied on duct surface by brush or spray, the no of coats can be 1 or 2 as to get specified thickness. The MS Ducts shall be allowed to hard dry before application of Fire Resistance coating. **Application Method:-**It is recommended to use brush/roller or spray for the application of Fire-Resistance Coating on Duct Surface. Due to the rapid drying of the coating, areas may be uniformly scaled by roller. Care must be taken to ensure that the Fire-Resistance Coating is applied uniformly. Large horizontal surfaces should be spray applied, but however it can be applied with brush or roller.

The Mixing of Fire-Retardant Coating and coverage area shall be as per manufacture recommendations. The Contractor shall provide all materials, accessories, spray equipment's, tools, inspection services and labor to satisfactory carry out works in best trade practice. All workmanship & installation techniques shall comply with the manufacturers "Application instructions" relevant Building Code Statutory requirements and applicable ASTM, BS, IS or BIS standards.

6.25 SPLIT AIR CONDITIONING UNITS

1. Scope

The scope of this section comprise the supply, erection, testing and commissioning of Air Cooled Split Units conforming to these specifications.

2. Type

The Split Units (Cassette/ Hi-Wall) shall be BEE 5 star rating (applicable as on date of supply of item) consist of Inverter compressor, motor, air cooled condenser, integral refrigerant piping and wiring, all mounted on a steel frame.

3. Indoor unit to be installed for Split Unit within building, shall be housed in insulated cabinet consisting of cooling coil, blower with motor, filter & insulated drain pan. Split unit must deliver specified capacity after taking into account losses due to piping length & site conditions.

4. Capacity

The refrigeration capacity of split unit shall be as per actual requirement work out by EPC Contractor.

5. Compressor and Motor

Compressor shall be inverter type and shall have dual pressure stat, and an operating oil charge. The motor shall be suction gas cooled and shall be sealed against dirt and moisture. The motor shall be suitable for $415 \pm 10\%$ volts or $230 \pm 10\%$ volts, 50 Hz, A.C. supply.

6. Refrigerant Piping and Controls

Refrigerant piping and fittings interconnecting compressor condenser shall be all copper and valves shall be brass / gunmetal construction. The refrigerant used shall be ozone friendly HFC R410A/ R-32 or green refrigerant.

7. Casing

The indoor & outdoor units shall be sectionalized / cabinet construction. Indoor units shall be consisting of fan section, coil section, filter section, and drain pan. Outdoor unit shall consist of condenser coil, fan & compressor. The compressor shall be mounted with the outdoor units. Each section shall be constructed of thick sheet steel all welded / bolted construction, adequately reinforced with structural members and provided with sufficient access panels for proper lubrication and maintenance. Base panel shall be constructed of fabricated steel structure provided with an under frame suitably braced. Drain pan shall extend under coil and fan sections with drain connections. Removable panels in fan and coil sections shall provide access to all internal parts.

8. Fan Motor and Drive

Fan motor shall be suitable for $415 \pm 10\%$ volts or $230 \pm 10\%$ volts, 50 Hz, A.C. Supply, Single phase, motors shall be provided with permanent capacitor. Motors shall be especially designed for quite operation.

9. Fan

Fan wheels and housing shall be fabricated from heavy gauge steel. Fan wheels shall be of double width, double inlet forward curve, multi-blade type enclosed in a housing and mounted on a common shaft. Fan housing shall be made of die-formed steel sheets with stream lined inlets to ensure smooth air flow into the fans, fan shaft bearing shall be oil/grease lubricated. All rotating parts shall be dynamically balanced individually, and the complete assembly shall be statically and hydraulically balanced.

10. Cooling Coil

Cooling coils shall be of fin and tube type having aluminum fins firmly bonded to copper tubes assembled in zinc coated steel frame. Face and surface areas shall be such as to ensure rated capacity from each unit and air velocity across each coil shall not exceed 100 meters per minute. The coil shall be pitched in the unit casing for proper drainage. Each coil shall be factory tested at 21 Kg. per sq.cm air pressure under water. Water coils shall be designed for a maximum working pressure of 10 kg/sq.cm. Tube shall be mechanically/ hydraulically expanded for minimum thermal contract resistance with fins. The number of fins per cm. shall be 4 to 5.

11. Vibration Isolators

The indoor and outdoor units shall be provided with ribbed rubber pad vibration isolators.

12. Painting

Shop coats of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, then coated with enamel paint to match the finish over the adjoining shop painted surface.

13. Performance Rating

The unit shall be selected for the lowest operating noise level.

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6.26 VARIBALE REFRIGERANT FLOW SYSTEM

The system selected is a modular system, with number of indoors connected to centrally located outdoor units. The outdoor units for all the system shall be air cooled type.

1. General Description

All the VRV/VRF air conditioners shall be fully factory assembled, wired, internally piped & tested. The outdoor unit shall be pre-charged with first charge of refrigerant. Additional charge shall be added as per refrigerant piping at site. All the units shall be suitable for operation with 415 V +/- 10%, 50 Hz + 3%, 3 Phase supply for outdoor units; & 220 V +/- 10%, 50 Hz +/- 3%, 1 Phase supply for indoor units.

2. Specifications of Outdoor units

- i) The outdoor unit shall be factory assembled, weather proof casing (Material of construction of casing shall be vendor's standard design), constructed from heavy gauge GI sheets steel panels and coated with baked enamel finish. The outdoor unit shall be completely factory wired, tested with all necessary controls & filled with first charge of refrigerant before delivering at site. Outdoors units of the VRV system shall be compact air cooled type.
- ii) The outdoor unit should comprise of Inverter Compressor.
- iii) Outdoor units suitable for cooling and heating, having all hermetically sealed inverter type Scroll Compressor(s), minimum two compressors for above 14 HP modules, microprocessor based Controller, top discharge type condensing unit(s), with R 410 A.
- iv) All compressors of outdoor unit must be Variable speed compressor only, which can work on Part load Suitable to operate at heat load proportional to indoor requirement. The unit shall be able to operate upto 49 deg. C in cooling mode
- v) The minimum COP shall be 3.5 at 100% load, 6.5 at 50% load and IEER not less than 6.5 at AHRI conditions. The OEM should have to present their data book for the above mentioned data.
- vi) The outdoor units must be suitable for up to 225 m refrigerant piping between outdoor unit & the farthest indoor units. Allowable level difference between outdoor unit & indoor units shall be 50 m in case of outdoor unit on top & 40 m in case of outdoor unit at bottom.
- vii) Allowable level difference between various indoor units connected to one out door unit shall be up to 15 m.
- viii) The outdoor units shall be suitable to operate within an ambient temperature range of 5 Deg C to as per site ambient condition in cooling mode; & 7 to 15 Deg C to 15 Deg C in heating mode.
- ix) The entire operation of outdoor units shall be through independent

remotes of indoor units. No separate Start/ Stop function shall be required.

x) Inverter compressor of the unit shall start first & at the minimum frequency, to reduce the inrush current during starting.

xi) Complete refrigerant circuit, oil balancing/ equalizing circuit shall be factory assembled & tested.

xii) The Outdoor unit shall have refrigerant cool PCB chamber for better operation at high ambient temperature.

3. Specifications of Indoor units

The units include pre-filter, fan section and DX coil section. The housing of units shall be light weight powder coated galvanized steel. Units shall have external casing of ABS Plastic for supply and return air.

3.1 4 Way Cassette type indoor units

- i. These units shall be installed between the bottom of finished slab & top of false ceiling.
- ii. Unit shall have provision of connecting fresh air without any special chamber & without increasing the total height of the unit (320 mm maximum).
- iii. The unit must have in built drain pump, suitable for vertical lift of 750 mm.
- iv. Unit must be insulated with sound absorbing thermal insulation material, Polyurethane foam. The sound pressure level of unit at the highest operating level shall not exceed 46 dB (A).
- v. The unit must have drain pump kit. The drain pump must be suitable to lift drain 700 mm (Min.) from the bottom of the unit.
- vi. The unit shall be ceiling mounted cassette type. The unit shall include pre-filters, fan section and DX-coil section. The body shall be light in weight and shall be able to suspend. The fan shall be aerodynamically designed diffuser turbo fan type. Unit shall have an external attractive panel for supply and return air.

3.2 4 Way Compact Cassette type indoor units

- i. The compact cassette unit should perfectly fit into ceilings and match the standard architectural modules, without the need to cut ceiling tiles.
- ii. The flaps fold tightly against the ceiling when operation stops so that the ceiling is affected only slightly even if air conditioning is installed.
- iii. Designed for simple & easy installation and maintenance. It should be slim in design only 268 mm in height even when an electrical box is located inside the unit.
- iv. The unit must have drain pump kit. The drain pump must be suitable to lift drain to 700 mm (Min.) from the bottom of the unit.

3.3 Concealed duct type units

- a) These units shall be ceiling suspended with suitable supports to take care of operating weight of the unit, without causing any excessive vibration & noise.
- b) The cold air supplied by these units will be supplied to the area to be air conditioned, through duct system specified in the tender.
- c) Each indoor unit must have electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling/heating as per the heat load of the room.
- d) The Sound Pressure level of unit at the highest operating level shall not exceed as per standard, at a vertical distance of 1.5 m below the units with duct connected to the unit.
- e) The unit must have provision of adding drain pump kit if required & specified. The drain pump must be suitable to lift drain to 700 mm (Min.) from the bottom of the unit.

3.4 Wall Mounted Units

- a. Wall mounted units must be compact & stylish design that does not detract from the décor of the room.
- b. Each indoor unit must have electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling/heating as per the heat load of the room.
- c. The unit must have provision of adding drain pump kit if required & specified. The drain pump must be suitable to lift drain to 700 mm (Min.) from the bottom of the unit.
- d. The sound pressure level of unit at the highest operating level shall not exceed as per standard.
- e. Refrigerant control in the indoor unit shall be through Electronic Expansion Valve.

3.5 Fresh Air

Fresh air Treatments Unit shall be suitable for VRV/VRF type of Unit. Fresh air unit to be connected to the VRV/VRF condensing unit & it shall be heat pump type to provide cooling in summer & heating in winter. This unit shall be capable of handling outside air temperature 4 degree to 46 degree. The unit shall include pre-filter, fan section & DX-coil section. The housing of unit shall be light weight powder coated galvanized steel.

1. Installation

- a) The units shall be mounted on ribbed rubber pads for vibration isolation. The EPC CONTRACTOR shall supply the required charge of refrigerant, lubricant and other consumables, for commissioning and testing of the equipment.

- b) The equipment shall be thoroughly tested and checked for leaks. All safety controls shall be suitably set and a record of all setting shall be furnished to the project supervisor.
- c) Providing and fixing M.S. structural support for condensing unit with vibration isolator pad in between support and structure and vibration isolation suspender and pads for evaporating units shall be in scope of EPC CONTRACTOR.

2. **Painting**

Shop coats of paint that have become marred during transportation or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the finish over the adjoining shop painted surfaces.

3. **Condensate Drain Piping**

All pipes to be used for condensate drain shall be PVC pipe conforming to IS: 4985 - Class I & all joints should be Gluing or solvent cementing as per manufacturer recommendation.

4. **Refrigerant Piping**

- (a) All refrigerant pipes and fittings shall be type 'L' hard drawn copper tubes and wrought copper fitting suitable for connection with silver solder. The copper thickness of wall shall be 20G/ 22G (0.7 to 1 mm)
- (b) All joints/ y-joints in copper piping shall be swaged joints using low temperature brazing and/ or silver solder. Before jointing any copper pipe or fittings, its interior shall be thoroughly cleaned by passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean of dirt etc. while construction of the joints. Subsequently, it shall be thoroughly blown out using nitrogen.
- (c) Refrigerant lines shall be sized to limit pressure drop between evaporator and condensing unit to less than 0.2 kg per Sq.cm.
- (d) After the refrigerant piping installation has been completed the refrigerant piping system shall be pressure tested using, Freon mixed with nitrogen at a pressure of 20 Kg per Sq. cm. (High side) and 10 Kg per Sq. cm (Low side). Pressure shall be maintained on the system for 24 hours.
- (e) The system shall then be evacuated to a minimum vacuum of 70 cm. of mercury and held for 24 hours, during which time; change in vacuum shall not exceed 12 cm of mercury.
- (f) All refrigerant piping shall be installed strictly as per the instructions and recommendations of air conditioning equipment manufacturers.

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6.27 REFRIGERANT PIPING

1.0 Scope of Work

The scope of this section comprises supply, installation, testing & commissioning of refrigerant piping as detailed below in specifications.

2.0 Refrigerant Piping

All refrigerant piping for the air conditioning system shall be constructed from soft seamless up to 19.1mm and hard drawn copper refrigerant pipes for above 19.1mm with copper fittings and silver-soldered joints. The refrigerant piping arrangements shall be in accordance with good practice within the air conditioning industry, and are to include charging connections, suction line insulation and all other items normally forming part of proper refrigerant circuits.

All joints in copper piping shall be sweat joints using low temperature brazing and or silver solder. Before joining any copper pipe or fittings, its interiors shall be thoroughly cleaned by passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean of dirt etc. while constructing the joints. Subsequently, it shall be thoroughly blown out using nitrogen.

After the refrigerant piping installation has been completed, the refrigerant piping system shall be pressure tested using nitrogen at pressure of 20Kg per sq.cm and 10 Kg per sq.cm (low side). Pressure shall be maintained in the system for 24 hours. The system shall then be evacuated to minimum vacuum if 700mm hg and held for 24 hours.

The air-conditioning system supplier shall be design sizes and erect proper interconnections of the complete refrigerant circuit.

The thickness of copper piping shall not be less than 20gauge for pipes up to 19.1mm and 18 gauge for bigger sizes.

S. No.	Sizes Diameter (mm)
a)	6.4 mm dia (OD) (Soft drawn) with tube thickness 1.2 mm with 19 mm thick insulation
b)	9.5 mm dia (OD) (Soft drawn) with tube thickness 1.2 mm with 19 mm thick insulation
c)	12.7 mm dia (OD) (Soft drawn) with tube thickness 1.2 mm with 19 mm thick insulation
d)	15.86 mm dia (OD) (Soft drawn) with tube thickness 1.2 mm with 19 mm thick insulation
e)	19 mm dia (OD) (Hard drawn) with tube thickness 1.2 mm with 19 mm thick insulation

f)	22.2 mm dia (OD) (Hard drawn) with tube thickness 1.2 mm with 19 mm thick insulation
g)	28.58 mm dia (OD) (Hard drawn) with tube thickness 1.2 mm with 19 mm thick insulation
h)	34.9 mm dia (OD) (Hard drawn) with tube thickness 1.62 mm with 19 mm thick insulation
i)	41.27 mm dia (OD) (Hard drawn) with tube thickness 1.62 mm with 19 mm thick insulation
j)	6.4 mm dia (OD) (Soft drawn) with tube thickness 1.2 mm with 19 mm thick insulation
k)	9.5 mm dia (OD) (Soft drawn) with tube thickness 1.2 mm with 19 mm thick insulation
l)	12.7 mm dia (OD) (Soft drawn) with tube thickness 1.2 mm with 19 mm thick insulation

6.28 VARIABLE FREQUENCY DRIVES (VFD) FOR HVAC SYSTEMS

1. Air quantity flow control

The VFD / VSD System shall function to supply variable air quantity in the air-conditioned area in response to the load variations including that due to variations in ambient conditions and filter cleanliness conditions, to maintain the inside designed temperature, RH and pressure conditions in conjunction with the humidifier and re-heaters. During the day hours, as per the time interval selected, the VFD / VSD System shall regulate the speed of the AHU to maintain the temperature within maximum designed temperature and positive air pressure inside the air-conditioned area. The positive air pressure shall be maintained by keeping a difference of minimum 15% in the airflow between the supply and exhaust air. However, under any circumstances during the day hours, the air flow rate will not fall below the 60% of the rated CFM of the AHU or 15 air changes, whichever is higher. During the rest of the night hours, the Programmable timer shall give a signal to the VFD / VSD to run the AHU at a pre-determined reduced speed so as to provide only 25% of the normal CFM or the minimum CFM achievable closest to 25% but not below 25% of the normal CFM. Due to the clogging of the air filter if the inside temperature conditions are not achieved even at 100% AHU speed then the VFD / VSD will close an N.O. contacts to activate an alarm. The VFD / VSD shall have the provision to switch over to the manual mode as and when required. The system shall comprise of dedicated Variable Frequency Drive (VFD) / Variable Speed Drives (VSDs) designed for HVAC applications to accept 2 feedback signals (from temperature sensor installed in the AC area and programmable timer controller) and have 2 programmable set points (inside temperature conditions, and 60% of the normal CFM condition as stated (above) using HVAC terminology, to regulate the speed of the AHU motors in response to the variations in load and filter cleanliness conditions to maintain temperature and Air flow differential in supply and exhaust conditions. In case, any additional sensor (s) including wiring etc are required to meet the system requirements the cost of that shall be deemed to be included in the cost of the VFD / VSD control shall have:

- RFI (Radio frequency interference) filters for EMC (Electro-magnetic compatibility) compliance.
- Voltage Vector Control technology to generate advanced sinusoidal output voltage, 100% true RMS value of the fundamental voltage at rated speed and nominal torque, cause no motor de-rating and keep motor temperature limits within permissible class B limits.
- Displays in user's friendly Alpha Numeric Characters for all operating parameters, programming parameters and faults.
- Built in energy meter.
- Built in run time counter.
- Local control panel (key pad)

The system shall also comprise a suitable programmable timer & PLC with required electronic components, to allow 2 feedback signals (Temperature & Minimum CFM)

to be passed on to the VFD / VSD during the day hours. In the night hours only one signal from the programmable timer shall go to the VFD / VSD to run it at pre-determined reduced speed. The room / space air temperature and air flow shall be sensed by a temperature and air flow transmitters, which shall generate suitable DC signal to provide feedback to the VFD / VSD, which in turn shall regulate the speed of the AHU fan to maintain the designed conditions as described above. VFD / VSD shall be designed, with built-in PID controller, control panel (keypads & display), IP 20 Protection in case inside the panel or minimum IP 42 Protection in case outside the panel, enclosure for use on standard centrifugal fans. The VSDs should not cause any de-ration of the connected motors and must ensure that class B temperature levels of the connected motors are never exceeded. The display should be in alpha-numeric characters and programming facility should be in user- friendly HVAC terminology. The VFDS / VSDs should be able to accept up to 2 feedback signal from temperature & air flow transmitter simultaneously and to program 2 set points in it.

The system shall also have following features incorporated:

- Heat sink over temperature protection
- Under voltage protection
- Over voltage protection
- Alpha-numeric display facilities
- ON indication
- Trip indication
- Selectable display of various parameters line voltage, frequency, speed, power, motor temperature percentage, VFD / VSD temperature percentage, KWH.
- Raise and lower speed push button in local mode.
- Frequency range variation from 0 to 50 Hz.
- Remote start and stop facility including indications thereof with necessary hardware and terminal blocks, including toggle switch etc. to over-ride remote start & stop at the time of maintenance / repairs.
- Off delay facility through timer or PLC with 30 sec to 120 sec. time delay, to be connected to air flow switch.
- Safeguard facility against single phasing.
- Tripping of AHU blower motors in response to the fire alarm signal from AFAS.
- Inter locking of Exhaust and AHU blowers such that power supply gets fed to exhaust blower only when the supply air flow is there.

2. Chilled water flow control

Variable Frequency Drive (VFD)/ Variable Speed Drive (VSDs) for controlling the chilled water flow rate in the secondary circuit may be provided when AHUs operation is for 24 hours and where the secondary chilled water system has been provided. Requirement and Specifications of VFD / VSD system shall be as follows:

The VFD / VSD System shall function to supply variable chilled water flow in the secondary circuit of air-conditioning system in response to the load variations including that due to variations in ambient conditions to maintain the inside designed temperature conditions. However, under any circumstances, the secondary chilled water pump speed shall not fall below the 30% of the nominal speed or any other suitable minimum speed as per the system requirement. The VFD / VSD shall have the provision to switch over to the manual mode as and when required and facility for the manual speed variation from VFD / VSD itself. The system shall comprise of dedicated Variable Frequency Drives (VFDs) / Variable Speed Drives (VSDs) designed for HVAC applications to accept two feedback signals (from differential pressure transmitters installed across the two farthest, most significant AHUs of the zone to select either maximum of the two or average of the two (as selected by the user) feedback signals using HVAC terminology, to regulate the speed of the secondary chilled water pump motors in response to the load variations. In case, any additional sensor (s) including wiring etc. if required to meet the system requirements the cost of that shall be deemed to be included in the cost of the VFD / VSD. The VFD / VSD shall have:

- RFI (Radio frequency interference) Filters for EMC (Electromagnetic compatibility) compliance.
- Voltage Vector Control technology to generate advanced sinusoidal output voltage, 100% true RMS value of the fundamental voltage at rated speed and nominal torque, cause no motor de-rating and keep motor temperature limits within permissible class B limits.
- The VFDs / VSDs shall have D.C. link reactors / harmonic filters integrated to minimize power line harmonics as per IEEE STD 519-1992.
- An automatic energy optimization feature shall be provided as standard in the frequency converter. This feature shall reduce output voltage, further to quadratic V/f characteristics, when the motor is lightly loaded and minimize the motor losses.
- The VFD / VSD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 160% torque for upto 5 seconds (for high inertic and high friction load).
- The VFD / VSD shall include Automatic Motor Adaptation (AMA) to optimize motor performance, improve start capabilities and compensate for motor cable variances. The AMA shall be carried out at motor stand still with no need for detaching the pump from motor.
- Unlimited output power circuit switching must be possible without the need for central circuit interlocking and without causing damage to the VFD / VSD.
- Auto-derating of maximum drive current shall be incorporated in VFD/ VSD to allow continued operation at reduced speed in case of VFD/ VSD over temperature phase loss or mains imbalance without damaging the VFD/ VSD.
- Displays in user's friendly Alpha Numeric Characters for all operating parameters, programming parameters, faults,
- Built in energy meter.

- In run time counter.
- Local control panel (key pad)

The system shall also comprise a suitable PLC if required, with electronic components.

VFD/ VSD shall be designed, with built-in PID controller, control panel (keypads & display), IP 20 Protection in case inside the panel or minimum IP 42 Protection in case outside the panel, enclosure for use on standard centrifugal pumps. The VSDs should not cause any de-rating of the connected motors and must ensure that class B temperature levels of the connected motors are never exceeded. The display should be in alpha-numeric characters and programming facility should be user-friendly HVAC terminology. The VFDs/ VSDs shall be able to accept up to two feedback signals from differential Pressure transmitters simultaneously and to program set points in it.

The system shall have following features incorporated: -

- Heat sink over temperature protection
- Under voltage protection
- Over voltage protection
- Protections against input transients, loss of A.C. line phase, short circuit, ground fault, frequency converter over temperature.
- Alpha-numeric display facilities
- ON indication
- Trip indication
- Selectable display of various parameters like output line voltage, output frequency, speed, power, motor temperature percentage, heat sink temperature VFD/ VSD temperature percentage, KWH, hours run, differential pressure.
 - Raise and lower speed push button in local mode.
 - Frequency range variation from 0 to 50 Hz.
 - Remote start and stop facility including indications thereof with necessary hardware and terminal blocks, including toggle switch etc. for override of remote start & stop of at the time of maintenance/ repairs.
 - Safeguard facility against single phasing.

Where both building management system and air quantity flow control/ chilled water flow control through VFD / VSD are provided for same application, control panel for sequencing of VFD / VSD shall not be required.

General Requirement

- The variable frequency drives/variable speed drive shall be Pulse Width Modulation (PWM) type, micro-processor controlled design.

- The Variable Frequency Drive (VFD) / Variable Speed Drive (VSD) should be IS/UL listed.
- The VFD / VSD shall be housed in a suitable enclosure
- The VFD / VSD shall employ an advanced sine wave approximation and voltage vector control to allow operation at rated motor shaft output speed with no derating. This voltage vector control shall minimize harmonics to the motor to increase motor efficiency and life. Power factor shall be near unity regardless of speed or load.
- The VFD / VSD shall have balanced DC link reactors to minimize power line harmonics VFDs / VSDs without a DC link reactor shall be as per IEEE STD 519-1992 with up to date amendments.
- Input and output power circuit switching can be done without interlocks or damage to the VFD / VSD.
- The following customer modifiable adjustments shall be provided:
 - Accel time.
 - Decel time.
 - Minimum Frequency.
 - Maximum Frequency.
- RS-485 Modbus/ BacNet I/P/ Ethernet/ Metasys N2 shall be available and provided.
- An automatic energy optimization selection feature shall be provided. This feature shall reduce voltage when lightly loaded and provide additional energy savings.
- The VFD / VSD shall be suitable for operation without derating. VFD/ VSD shall be suitable for operation in environments up to 95% non-condensing humidity.
- The VFD / VSD shall have inbuilt real time clock.
- The VFD / VSD shall have detachable alphanumeric / graphical multi line display.
- The VFD / VSD shall be capable of displaying the following information in plain English via a graphical display:
 - Frequency.
 - Voltage
 - Current
 - Kilowatts per hour
 - Fault Identification.
 - RPM

6.29 VARIABLE AIR VOLUME (VAV) BOXES

- i) These shall be of the low velocity variable air volume boxes without re-heatcoils, and shall be of open protocol as marketed by a firm specializing in this field. The contractor shall supply and install units to the quantity and locations as specified.
- ii) The unit shall be complete with damper, airflow ring, and solid-state electronic controls to provide accurate room temperature control. The damper shall be aero foil type construction with bearings.
- iii) Boxes shall be supplied with all internal attenuation treatment and acoustical damped casing necessary to achieve the required noise criteria. Casing shall be of 22G GSS minimum fitted with a completely sealed, easily removable means of access to all internal parts. Access to all boxes must be from the underside only.
- iv) The actuator shall be of 24V AC Bi-directional, direct coupled to the damper shaft. The required transformer to step down of the voltage range from 230V to 24V shall be part of the unit. The power point with an isolator near the VAV will be provided by other agencies.
- v) The unit shall be complete with transformer, access panel and other accessories as per the standard.
- vi) The noise level shall be less than 35dbA.
- vii) Maximum allowable static pressure to the boxes for its satisfactory operation shall not exceed 0.10WG, otherwise fan and motor selections may be affected.
- viii) Boxes shall be able to reset any air flow between 10% and the maximum air quantity that the boxes can handle without changing orifices or other parts. Air quantity limiters will not be accepted.
- ix) A suitable device shall be provided for the field adjustment of minimum airflow. All boxes shall be initially factory set at minimum air quantity of 10% and maximum quantity of 110% of the design requirements.
- x) Under shut-off conditions, all boxes shall not have air leakage more than 2% of the maximum air quantity at 75mm static pressure.
- xi) The VAVs shall be used in standalone mode complete with its own temperature sensor and controller and shall perform the function of maintaining the temperature and airflow.
- xii) Where ever specified, the VAVs shall be BMS compatible to enable to network the VAVs to a Network Control Unit and onto BMS. In this mode all VAV data shall be available at the BMS workstation and it shall be possible to change set points and flow settings from the BMS workstation. All such controllers used for the control of VAV boxes shall be compliant with BACnet/ MODBUS protocol and be freely communicable to third party BACnet/ MODBUS IP controllers.

All boxes shall be electrically controlled. The boxes shall be pressure independent.
- xiii) VAV Box shall have provision to support from floor/ wall/ ceiling and in vertical /horizontal condition.

6.30 AIR CURTAIN UNIT

1. Scope

The scope of this section comprises the supply, erection, testing and commissioning of Air Curtains units conforming these Specifications.

2. Type

The Air Curtain units are Centrifugal Type Non Re-Circulating, preferably installed horizontal to the ground. Installed with anchor fasteners to the wall or mounted to the ceiling or frame with proper supports. The discharge nozzle shall be uniform all through, and the Air curtain shall fully cover the Door opening.

3. Capacity

The Air Curtain should be sized according to the width of the Door, and Air throw shall be selected as per the height of the Door.

4. Cabinets

Cabinets are constructed of 18 SWG CRCA iron sheet steel and powder coated. Corners are rounded without break lines. The cabinets have good finish and the access panels and the mountings are so provided for easy removal. All the nuts and bolts visible are nickel coated.

5. Blower Housing

The blower housing are constructed of pre coated sheet of 26 SWG Thickness, with plastic Molded end plate in ABS 300 with plastic Inward cones. The Housing is engineered in vortex design so as to provide the required outlet velocity with minimum noise level.

6. Fans

Fans installed in Air Curtain are centrifugal, forward curved double inlet, lightweight Dynamically balanced made in Plastic (ABS 300 Fire Retardant/ Anti Static) by the process of Injection Molding. Impellers have Die Cast Aluminum double ended Hubs. Blades are made in Aerodynamic Design. Performance of Impellor is tested as per AMCA Standards and Guaranteed.

7. Motor

Motor are 220 10% volts, 50 cycles single phase, four pole with START & RUN type capacitors. Motors have been provided with Thermal overload protectors. The Core is made in "CRNO" (Cold Rolled Non Oriented) Silicon Sheet. Motors have extended shaft on both the sides, with 15mm as the shaft Diameter. The Motors have 2RS Grade of Bearings, for friction free and noise less movement.

8. Motor Mounting

Motor Mounting have been so provided that it should have 24 Nos. of vibration isolators between each motor and the chassis, so placed that it can dampen vibration in all the axis i.e. X, Y and Z. Vibration isolator are made in silicon rubber, to resist Temperature rise.

9. Painting

Powder Coating is done on the unit. The colour of the powder used is Ivory from a reputed manufacturer. Proper treatment shall be done on each panel before powder coating.

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6.31 ULTRAVIOLET GERMICIDAL IRRADIATION (UVGI) SYSTEM

Ultra Violet Germicidal Irradiations, (UVGI) System to be installed inside the AHU/Duct for Improvement of Indoor Air Quality and/or Energy Saving (when installed inside the AHU's) as per Specifications. The Average Life of UV lamps shall be 12000 hrs.

The UVGI System shall consist of UV lamps, parabolic reflector (Reflector only in case of AHU mounting) with its mounting assembly and control panel. The Control Panel shall be mounted outside the AHU and should Consist of ballast, hour meter, MCB (or disconnect switch), Indicating Light. The work to include inter connected wiring (UV resistant) between the UVGI lamps and its panel.

The UVGI System should be designed to achieve at least 90% kill rate per pass of all air borne bacteria and virus. The design intensity of the lamp should be based on wavelength 254 nm. It should be ensured the lamp should not perform at ultra-low wavelength 180 nM or lower, to ensure no uncontrolled and unmodulated ozone is put out by the lamp.

UV lamp shall be fabricated out of special high transmission Quartz Glass and of the high output. UV lamp shall not produce ozone or other secondary contamination and to substantiate this the lamps shall be tested by an approved Indian lab for output performance of 254 nm. Lamp manufacturer to submit the certificate from this lab. The lamp shall be high output type and should not be lower than 800 mA.

The EPC contactor shall submit the Coil Size and CFM for AHU mounted application and Duct size with CFM for Duct mounted application. The length of straight duct should be provided by the Contractor at site.

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6.32 DRY SCRUBBER

1. SCOPE

The scope of this section comprises the supply, erection, testing and commissioning of dry scrubbers comprising of electrostatic sections with auto wash module for use in F&B exhaust/ grease/ exhaust air treatment.

2. CAPACITY

The air moving capacity of unit shall be as design.

3. Electronic Section Blower Section

The blower section shall be constructed out of 16G GI sheet in folded construction and shall include Centrifugal SISW fan and shall be complete with individual motor (motor out of hot air stream) and drive and shall be mounted C Channel frame and Cushy Foot or Spring Mounts. The fan shall have a capacity not less than the one specified in the catalogues and shall be constructed and rated based on delivery against the rated static pressure with the media and filters in place. The fan will be of riveted construction and made with GI sheet of required thickness. The fan wheel will be of the multi blade type and mounted on two self aligning pillow block bearings of the requisite size. The fan shall be run with the help of groove drives as per the recommendation of the drive supplier. The blower housing will of the Pittsburg joint construction and the drive will be provided by a motor of adequate capacity. The motor plate will be constructed out of 6mm MS or heavier metal with slotted holes, which permit belt adjustment in both the direction. The outlet velocity of the blowers will be kept low.

4. Cabinet Fans

The construction of the cabinet fans shall be identical with that of the air washer unit except that the cabinet fans will not have filters and humidifiers. 8. Electrostatic precipitator

Ionizer: Stainless steel spiked ionizers to create high voltage DC field.

Collector Plate: aluminum collector plates which should be alternatively charged positive & negative with large collecting area with 14" deep cell, to work as magnet for charged smoke & oil particles

Average efficiency of 90-95% in single pass as per ASHRAE test method with UL certified.

Electrostatic Precipitator should be able to charge particles from 0.01 micron to 10 micron through solid state power supply

Collector cell should be of permanent type and slide out facility for easy removal for cleaning.

5. Power Supply

Power supplies shall be 100% solid state and operate on 230 VAC, 50 Hz, 1 Phase input and provide a dual high voltage output of (+) 12 to 13 KVDC for the ionizer and (+) 6.0 to 6.5 KVDC for the collector. Module of capacity above 3000 CFM shall be equipped with Pulse width modulating (PWM) to maintain the specified collection efficiency by maintaining a constant charge in the event of Low/High Voltage from source thus ensuring that the unit functionality is not affected with these voltage fluctuations. Power Consumption should not be more than 50 watts per cell.

System should be fitted with interlock switch for safety.

The system should be able connected to a fan section to achieve airflow of 500 FPM across the air cleaner and should be interlocked with the fan to prevent dry run of the units.

BBB ✕ AAA

INTEGRATED BUILDING MANAGEMENT SYSTEM (IBMS)

7.1 INTEGRATED BUILDING MANAGEMENT SYSTEM (IBMS)

1.0 System Description

BMS System- All E & M services i/c low and high side of the AC plant shall be monitored &/or controlled with recording, display, analysis, hardware and software for optimization of electrical load and energy conservation, and all parameters of all other E&M Equipment's Services, Utilities etc. The integration of all systems shall be achieved through software programs, electronic components, and hardware packaging and communication network.

Detailed requirement & technical specifications of Building Management System (BMS) are indicated hereunder. Bidder is required to submit technical brochures of offered equipment.

The Building Management system (BMS) shall be provided at Keshod Airport, which mainly have control & monitoring of HVAC system and status monitoring facility for other installations like Elevators, Escalators, Fire Fighting System, Fire Detection & Alarm System, Power Supply System, Water Supply System and STP, WTP etc. The control and monitoring desk of BMS is generally provided at BMS Control Room.

Monitoring system also required to be provided in the AOCC/ Terminal Manager Office for better monitoring & coordination. The BMS system shall also have monitoring facility of BHS System, Flight Information Display System (FIDS), Public Address System (PA System) and provision for monitoring of ALCMS for AGL system.

The major Hardware components of the proposed IBMS System are:

- Operator workstations.
- BMS Server Active & Stand-by x Printer
- IP Direct Digital Controllers (DDC)
- Network Supervisors/ Gateways
- Field devices like sensors and actuators and controllers
- Integrator for hardware/software integration of third party systems
- Signal & Communication cables
- Network connectivity equipment

Operator workstation shall be latest generation specification desktop computer that shall be using a latest gen Intel i5/i7 processor. These shall act as Man Machine Interface (MMI) for maintenance team with IBMS Servers. Operator Workstation shall run IBMS User interface using web browser applications. An Operator shall be viewing & performing operation controls from Operator workstations. Operator workstations shall use the Windows based operating system so that popular business software's can run concurrently with the BMS software. To display high resolution 3D graphics, all operator workstations shall have colour monitors with Full HD screens.

To prevent mixing of alarms with report printouts, there shall be two types of printers: Alarm printer & Report printer. If an alarm printer is off-line, alarm messages shall automatically be routed to the report printer to ensure that alarm messages are reported.

Description of Plant Operation: Air Conditioning System Water Cooled Chilling Machines. Software integration of the micro-processor panel of water-cooled chilling machine with BMS. All the points displayed on the chiller micro-processor panel shall be duplicated on the BMS screen.

- a) Enable and disable each chiller unit through BMS.
- b) Monitor status of each chilling unit on BMS and subsequently give alarm on failure.
- c) Sequence each chilling unit through BMS to maintain equal run time.
- d) Carry out chilled water temperature reset with respect to chilled water valve Position at the AHU's through BMS.
- e) Control and monitor motorized butterfly valves in chilled water line through BMS for isolating the flow through machine during shut-off period of each machine.
- f) Monitor chilled water supply temperature at the outlet of each chilling machine through BMS.
- g) Monitor manual operation status of each machine through BMS.
- h) Monitor chilled water temperature reset.

Chilled Water Pumps

- a) Start-stop each pump through BMS as per demand.
- b) Sequence each pump through BMS to maintain equal run time
- c) Monitor any pump being switched on a manual basis through BMS.
- d) Carry out software integration with BMS for secondary chilled water pumps VFD panel for varying the speed as per the load.
- e) Monitor status of pump through BMS
- f) Perform all above functions for hot water system also.

General

- Integrated Building Management System is proposed from the point of view of smart buildings and energy conservation.
- Main IBMS server shall be set up at control room or specified otherwise at later stage by E-in-C and complete campus shall be monitored and controlled from there as per the philosophy.
- Required number of DDC controllers shall be provided as per I/O summary and requirement (with keeping 15% extra in each DDC controller.
- The total no of I/O points as given in I/O summary is an estimation and minimum requirement. The exact nos. will be higher as per detailed design for monitoring and control of all Services in IBMS as below:

- BMS shall work upon open protocols like BACnetIP and it should be able to integrate 3rd party systems communicating on Modbus RTU/ Modbus TCP/IP/ RS 485/ BACnet MSTP etc.
- Main Server shall be provided with redundancy.
- All Monitoring and Control equipment like temp. sensors, CO sensors, other sensors, transducers, flow meter, other switches, etc. are within the scope.
- Potential free contacts shall be provided with each device to be controlled through IBMS.
- All energy meters shall be provided with RS-485 port requirement.

Integrated Building Management System is proposed for the following:

- Monitoring and data logging from various services.
- Provision for sharing of monthly energy and water consumption data of the project by connecting with the GRIHA online benchmarking platform.
- Controls for various services.
- Monitoring, control and data logging is proposed for following services:
 - All high side HVAC equipment shall be monitored and controlled by a dedicated chiller plant manager. This chiller plant manager shall be remotely connected to BMS for data logging.
 - All low side HVAC equipment like AHUs, ceiling suspended AHUs, Fan coil units, ventilation fans etc.
 - Water supply system, WTP, STP and SWM shall have their dedicated plant managers (panels with PLC). These plant managers shall be remotely connected to BMS for data logging.
 - Access control system to be linked with Fire alarm system. The data shall be given from FAS System on open protocol Bacnet/IP to integrate with IBMS so that in case of fire, access control shall be bypassed (Provision for this to be made in BMS system for installation in future).
 - All other services as per the table given for monitoring and control.

Sl.	E&M Service Description	Monitoring	Control
1	Chiller Plant incl. Water-cooled Chillers, primary, secondary pumps, condenser water pumps, cooling tower etc.	Yes	Yes
2	All AHUs (floor mounted and ceiling suspended)	Yes	Yes

Sl.	E&M Service Description	Monitoring	Control
3	All plant room and Pump VFD integration	Yes	Yes
4	TFA AHU	Yes	Yes
5	All Fan coil units, treated fresh air units, Heat Recovery units, etc.	Yes	Yes
6	All Ventilation fans, pressurization, exhaust, smoke extraction system fans, etc.	Yes	Yes
7	All HT panels, APFC, Transformers, RTU, RTCC, fuel tank, AMF panel, all LT panels, energy meters of substation's panels and for EV charging etc.	Yes	-
8	DG sets	Yes	-
9	UPS	Yes	-
10	Passenger Elevators (Lifts)	Yes	-
11	Façade lighting & special occasion lighting	Yes	Yes
12	Fire Alarm system and provision for Access control system	Yes	-
13	Firefighting pumps	Yes	
14	Water supply system for domestic, soft water and recycled water i/c pumps, panels, etc.	Yes	
15	Tank level indicator - (Low, High, Mid) for all UG and OH tanks	Yes	-
16	Dedicated plant managers (panels with PLC) for STP, WTP and Waste composter	Yes	-
17	All equipment and sensors of Solar power generation system	Yes	-
18	VRF based Air-conditioning system integration	Yes	Yes
19	Internal Lighting Automation System integration	Yes	Yes
20	Energy metering for retail/commercial	Yes	No
21	Spare I/Os - 15%	Yes	Yes
22	Any other E&M service as required within the EPC contract.	As required	

Variable Speed Drives

To carryout software integration with BMS for VFD to control air quality and temperature in the space.

Ventilation & Smoke Exhaust System

- Control start/stop of each fan.
- Indicate any unit running in manual mode and subsequently give an alarm. Pressurization Fans
- Monitor start/stop of each fan.
- Monitor the status (electrical) of each fan

Electrical System

- Substation & LV Panel including capacitor panel.
- Monitor Incoming medium voltage
- Record KW consumption of main & sub distribution board as per GRIHA requirement.
- Monitor incoming voltage/frequency reading at low voltage panel
- Monitor current reading at LT panel.
- Monitor motorized breaker status, if any
- Solar Generation data, EV charging
- Energy metering

DG SETS

DG on/off, Battery, DG Oil tank level, HSD storage oil/pumps monitoring etc.

UPS

UPS on/off status, Battery Status etc.

Plumbing Equipment

- Hydro-pneumatic Equipment
- Status of each pump through a differential pressure switch and maintain a Log of runhours.
- Status of each pump through the electrical panel.
- Monitor line pressure of hydro pneumatic system.
- Monitor line pressure in the fire header.
- Water metering consumption data

Sewage Treatment Plant

Monitor status through an Electrical contact.

Water Tanks

- Fire water storage tanks
- Municipal water tanks
- Treated water tanks

Monitor water level alarms for tanks through a level switch/level transmitter and give an alarm for high/ low level.

Fire Fighting System:

- Monitor status of each of the above pumps through a differential pressure switch.
- Monitor line pressure through a pressure transmitter.

Note: Detailed input/ output Matrix showing AI, AO, DI, DO points shall be prepared upon finalization of all MEP equipments.

Integration:

- BMS shall be integrated with BHS system.
- BMS shall be integrated with Elevators system
- BMS shall be integrated with PA system.
- IBMS shall be integrated with Flight Info. Display System over open protocol such as BACnet, Modbus.

Software

Latest software from the same OEM supplier. Minimum 5 user license of the software with lifetime license shall be provided.

Monitoring facilities including work stations shall be provided at five locations.

The EPC Contractor shall provide of BMS system to be provided as per specifications laid down below in subsequent sections.

Besides requirement specified under different section(s) - scope of work & particular specification and in detailed specification of this packages, the following some highlighted in general are to be followed.

The system shall comply in all respects with this equipment specifications and appended drawings and standards.

The BMS system must offer forward and backward compatibility.

1.1 Description

General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers I.P. network controller (as desired) and a web-based operator interface. Depict each mechanical system and building floor plan by a point-and-click graphic. A web server with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface subject to all network security applications in place.

The system must be able to handle natively different disciplines in a building: Building Automation, Fire, and The disciplines must allow distribution across independent servers if required. Scope of access for controlling and monitoring discipline data must allow customization per user in every owner station. Each owner station must be able to be assigned one or more disciplines, allowing customizable single or multiple discipline access mode.

1.2 BMS Schedules

The BMS agency shall provide the following schedules relevant to the requirements of the Particular Specification:

- A points schedule showing each proposed connected point to the system.
The points shall be arranged as schedules showing the points allocated on a

plant-by-plant basis, the controller specification(s) selected, I/O capacity supplied and the spare I/O available for future use. Any points schedule supplied with this specification shall be considered as supporting information only. The BMS specialist shall be responsible for ensuring the correct allocation of points required for meeting the performance specification.

- A schedule summarising the field hardware and indicate the quantities, types, manufacturer and duties of the devices. Field devices from the BMS vendor shall be used where possible.
- A Description of Operation detailing the operation of the proposed system.
- Where a system comprises more than a single network the BMS tenderer shall include a diagram within the tender showing the layout of the LAN's and interconnections.

The BMS specialist shall supply the necessary hardware and software as below:

1.3 Software Management Station- Management level requirements

General

All information comes together at the management level. The management level is the graphical, interactive interface for the operator to the automation station and the integrated plants and plant parts.

The operator can display, query, process, save, or print any plant information via the peripheral units at the management level. System operation must be simple, i.e. dialog driven. The plants are displayed in synoptic images and the values and states are presented and displayed dynamically. Special programs are used for higher control, optimization functions, maintenance and energy management.

Multi-discipline

The system must be able to handle natively different disciplines in a building: Building Automation, Fire, Access Control, Intrusion, Video. The disciplines must allow distribution across independent servers if required. Scope of access for controlling and monitoring discipline data must allow customization per user in every client station. Each client station must be able to be assigned one or more disciplines, allowing customizable single or multiple discipline access mode.

System openness

The control system support standard protocols used in building technology, including BACnet, OPC server/client, Modbus.

Data exchange via various subsystems

If several subsystems are used, various data must be exchanged between the automation stations (outside temperature, demand and coordination signals, etc.).

Automate recurring tasks

The building automation and control system must take care of recurring tasks to lower the operator's workload. This includes, for example, cyclical report generation triggering, plant release at various conditions, or automatic adjustment of setpoints or alarm limits.

Reactions

The system must allow automatically executable actions to be programmed at the management station when set conditions are verified. Conditions can be time-based, event-based, on change of values or on a combination of some or all. When conditions are met, the system shall execute a pre-configured list of commands.

Scripting

The system must provide a Script Editor to create scripts based on a known scripting language. The script engine must allow the manual execution of scripts manually by the operator, or automatic execution triggered by the system based configurable conditions. Among others the scripts must support:

- Commanding of objects
- Reading attributes of object
- Subscription to value changes
- Read/Write text files
- Loading of external DLL's
- Mathematical/logical operations

Drafted for use by fire detection and security systems (UL certified)

The management station must have passed Underwriters Laboratories (UL) performance and environmental tests. The management station must offer all relevant functions to connect comfort and fire detection systems:

- Display and handle events
- Graphically monitor and control the fire detection system
- Highlight the highest priority events.
- Direct navigation to the element triggering an event.
- Quickly go to user-defined instructions and graphically display event locations.
- Save and query activity data from the fire detection system.
- Distribute fire monitoring and control capabilities.
- Provide operating instruction checklists for operators during stressful situations for handling fire events.
- Send automatic remote messages of impacted device per e-mail.
- Display and plan automatic history reports.

System-wide self monitoring

The system must be capable of monitoring running applications, printers, and all connected subsystems. The system must report an event in case of an exceptional state.

System analysis

Detailed analysis on system and user activities must be available in chronological order.

SCADA platform

The management station must be based on a SCADA platform that is compatible with the BACnet B-AWS profile. It must permit integration of any building installation including HVAC and lighting.

Operating system for building automation and control system

All data servers, operator stations, etc., for the BAC system must be compatible with the most current, generally available Windows 64-bit operating system. As a result, the current version of Windows (at least 6 months after release by Microsoft) as well as a minimum of the last Version is supported. Modifications to the customer network must be possible. The BAC system must therefore be installable on any common PC and offer a multitasking environments where a user can run multiple applications simultaneously.

Ecosystem

The system must provide the means to develop proprietary drivers, not supported by the system natively for communication with 3rd party subsystems and devices, or exchange of data with external applications.

The system must also provide possibilities to extend the functionality by adding new libraries containing scripts, graphic symbols, graphic templates or object models to support subsystem integration or optimize automated tasks.

Long term storage

The system must be able to store and archive data for a period of more than 10 years, allowing as an option segregation of stored data in different groups that can be tuned individually with different recording frequencies. Remounting of offline archived data must also be allowed.

Distributed architecture

The platform must allow a distributed architecture across different systems to enable scalability (up to 500,000 objects) and separation by discipline and/ or location. The distributed architecture must provide a single system image to the end user. The functionality that is available in a single system must be also available in a distributed architecture.

Front-End Processor

The system must support the separate installation of communication drivers for subsystem communication on a different server.

Help functions

The software includes an online help, context sensitive as well as indexed, a glossary, and can be searched by terms or sentences.

System up-to-date

Product lifecycle

The system provider must offer a transparent product lifecycle to ensure the required consistency. All equipment offered for this project must be contained in the current product portfolio. The existing system environment must allow for easy and smooth integration of devices and extensions.

System continuity

Products employed must be labels with a brand for a global standard that secures the interaction of products from various manufacturers. Products bearing these brands can also be employed together when manufactured at a interval of more than 10 years.

Hardware requirements

Minimum hardware requirements

Standalone system (one client)

A full installation on one single computer machine is required. The hardware and software environment must fulfill the following definition:

- Type: Workstation Tower
- Processor: Intel Core i7 or higher
- Memory: 16GB
- Harddisk: 1 TB (for example Western Digital Green/Red) 2
- Network card: Gigabit speed
- Graphic Card: Onboard graphics adapter (for example Intel 4600HD), or Mid-range graphics card (for example GeForce GT 730, AMD Radeon, Radeon R7 250)

Recommended software environment

- Windows 10 Professional (64 bit) or higher
- Windows Server 2012 R2 or 2016 or higher
- Microsoft SQL Server 2012, SQL Server 2014, SQL Server 2016 (Express, Standard or Enterprise) or higher
- Anti-virus software- shall be provided (and suitably renewed during DLP and AICMC period).

Server system (up to 10 clients)

One client/server system for mid-sized sites with a high data transfer rate is

required. The hardware and software environment must fulfill the following definitions:

- Type: Server tower
- Processor: Core i7 4th generation (for example Intel Core i7-4770K), Intel Xeon (for example Intel Xeon E5-1630 v3, Intel Xeon E5 1620 v2) or higher
- Memory: 32GB
- Hard Disc: 2 * 1 TB hard disk (for example Western Digital Red, Seagate Constellation ES.3)
- Network card: Gigabit speed
- Graphics card: Onboard graphics adapter (for example Intel 4600HD), or Midrange graphics card (for example GeForce GT 730, AMD Radeon, Radeon R7 250)

Recommended software environment

- Windows 10 Enterprise, multilingual, 64 bit or Windows Server 2016, multilingual, 64 bit or higher
- Microsoft SQL Server 2012, SQL Server 2014 or SQL Server 2016 (Standard or Enterprise) or higher
- Anti-virus software- shall be provided (and suitably renewed during DLP and AICMC period).

Network requirements

- Local network
- 1000 Mbps up/down
- Latency less than 10 ms

User profiles

Plant overview

Individual views

Individual, specific or user defined views must be adjustable for the plant overview. The views must cover various electrical and mechanical installations or follow geographic or organizational criteria and permit a customized, hierarchy view, that depicts the management station, control systems, plant geographic layout as well as relationship of the mechanical facilities.

User privileges

The building automation and control system must allow users to define, change, or delete predefined reactions as per their user privileges.

Multi-lingual

The user interface must support a minimum of 3 languages at the same time.

Graphics

General

Operating interface to CAD system

The user interface must allow users access to various system diagrams and floor plans using graphical depictions, menu selections, and data point assignments. The graphics software must also permit the import of CAD symbols (DWG, DXF format) or scanned images for use in the system.

Operating messages

Operating message must be able to be displayed and evaluated on the management level. Graphics must be able to display data point states that are overwritten by a local priority switch. This on data points that were developed to supplying by local override.

Full graphics mode

A fully graphics-based management level with ergonomic and freely scalable images must be available. The system must be developed to operating, monitor, optimize, and log all connected automation stations in real time.

Graphics generation

Operators must be able to add, delete, and edit system graphics and state texts for digital data points from the standard user interface without external or special tools.

Navigation

A hierarchy tree can support as an option navigation to the various graphic images. Graphic displays must include the ability to dynamically zoom and switch among various layers with different information.

In graphics commanding

The system must offer graphic objects which can be used to command or control the system. At a minimum, sliders, buttons, text boxes, dropdown lists and radio buttons must be included

Visualize the quality state in the plant graphics

A violation of energy efficiency limit values for measured values of primary plants (e.g. centralized air handling, energy generation) must also be displayed in the plant graphic directly on the application components or function. The parameters for monitoring, evaluating and forming the quality state can be set directly in the plant graphic based on read and write access rights. As an alternative: Make possible the simple navigation to an appropriate user program.

Pictures

Graphic symbols and standards

Plant graphics must meet the ergonomic needs of the operator. The displayed graphic symbols must correspond to the generally valid standard for HVAC symbols (DIN EN 62424 (VDE0810-24)) and ASHRAE guidelines. The symbols must be supported as 2 and 3 dimensional graphics. The ability is required to create colored floor displays and system diagrams for each mechanical facility including AHU, chilled water plants, hot water boiler systems, and room operator units. Associated print outs of standardized plant images must be added to the bid.

Object-oriented graphics

The building automation and control system must offer dynamic, high-resolution graphics. The graphics must be object-oriented. Each symbol must be able to display several states in the same, consistent format. At the same time, several views must be able to be open concurrently, and all views must be updated dynamically.

Continuous update and display

Measured values, set points, user settings, and alarms must be displayed immediately and continuously. State changes must be indicated via symbol, e.g. using animation or changing the color, in general, however, graphic presentation, or text.

Energy management

Energy measuring functions

Monitor control process quality

The entire system must be monitored for control deviations. A corresponding alarm message must be generated if a measured value exceeds or drops below a specified setpoint for an extended period of time for a given control process.

Counter values, pulse count

Pulse inputs must support implementation and display in real process values for further processing in the building automation and control system. Operators must be able to set start values, correction values, and limit values via the operator units.

Counter values, pulse count, and absolute value acquisition

Pulse inputs must support implementation and display in real process values or direct readout of absolute values for further processing in the building automation and control system. Operators must be able to set start values, correction values, and limit values via the operator units.

Managed Meters

The system must be able to detect energy meter rollover and react to it showing the real figure of the accumulated energy consumed. It must also support the exchange of energy meters taking into account the latest reading of the replaced meter so that the energy values for the new meter continue adding up on it.

Integration of power meters

The system must support the integration of power meters and provide standard electrical symbols as well as dedicated graphics and templates for meters or electrical components commonly used in data centers, such as PDUs and UPSs.

Energy and Power reports

The system must be able to provide energy and power reports to visualize:

- Load profiles
- Maximum power
- Energy consumption
- Comparison of consumptions

Analysis of the data must be done on the local machine, not on a cloud based solution.

Scheduler programs

General

Management via central scheduler programs

Operate all scheduler programs online from the management level to achieve consistent, transparent operation of all integrated systems and subsystems.

Scheduler programs

The system must offer the ability to operate schedulers on automation stations as well as support management station-based time scheduling.

Each currently used plant image must offer user-friendly scheduler operation.

Scheduling and override

Providing calendar type formats to simplify time and data planning and override building operation is required. Time definitions must be located on the PC workstation and building controller to ensure scheduling even if the PC is offline. Providing override access through menus, graphical mouse, or function keys. Providing the following operations at a minimum:

- Comprehensive support of all BACnet objects for scheduler, calendar, and commands.
- Daily and weekly schedules
- Ability to compile multiple data points into a logical command group to simplify scheduling (e.g. Building 1 Lighting)
- Planning predefined reports.
- Ability to plan at least 10 years in advance.
- Provide filters for schedulers by name, time, frequency, and schedule.
- Provide sorting schedulers by name and schedule type.

Scheduler program types

Customized scheduler program

The user can customize the schedule defining the operating mode for each plant.

Switching times are defined via weekly schedule. Overriding recurring weekly schedules via local or global exceptions as well as operation via any operator unit must be possible.

Customized calendar

Local or global calendar exceptions must be able to override the plant-specific weekly scheduler program. Equal calendars must be assigned priority over each other. Calendar operation must be possible via all operator units.

Building automation and control system operation

Multiple user system

Create calendar online

Calendar programs must be able to be remotely created online to provide service personnel a high level of flexibility.

Create scheduler online

Scheduler programs must be able to be remotely created online to provide service personnel a high level of flexibility.

Create offline trend online

Trends, that also trend offline, must be able to be remotely created online to provide service personnel a high level of flexibility.

Multiple, concurrent users

Multiple users must be able to work concurrently on various workspaces on the building automation and control system for efficient and comprehensive work. Plants must simultaneously be analyzed and e.g. monitored or operated via a remote station.

Security

Access protection

Different persons maintain and operate the plant. For this reason, passwords must be assigned to authorized persons to guarantee transparency for tracking or authorization purposes. A minimum of four different rights must be assignable.

- Administrator.
- Program and graphics creation.
- Operation to change or adjust set points.
- Guest.

Windows authentication

The building automation and control system password management must meet the customer's IT guidelines. In other words, the customer's corporate standard also apply to the BAC system. As a consequence, password management and the associated properties must comply with standard Windows log on and "track" the operator on each workstation.

Alarm handling

General

Alarm function

The automation station contains an image of the physical data points. Each data point must be alarmable. Parameterization via operator units must be possible. The alarms require acknowledgement.

Alarm message

Alarms from the automation station must be displayed on the operator units within 1 second. Alarms must be acknowledged or acknowledged and reset dependent on access rights. Delay times (e.g. feedback supervision, triggering of differential pressure monitor, filter) must be changeable via operator units.

Alarm suppression

Lower priority messages, undesired reactions from objects or entire plants must be capable of being suppressed during commissioning, plant servicing or automation station start up.

System safety

High availability

High availability is expected from the building automation and control system. This results in greater data availability, greatly reducing any down times.

Alarm generation

Message handling

The building management system must support alarms generated at the automation level (substations).

Alarm routing

Media independent formats

Current alarms may need to be routed independent of media at certain times to a central service (printer, email, SMS, and mobile apps). The number of data points that can be configured for remote messaging of alarm conditions as well as the number of remote devices that may receive system messages may not be limited. The system must support the sending of encrypted e-mails.

Alarm message escalation list

The system be able to be configured to send messages to individuals or a group of people and various messages to different remote devices by message priority. It must also be able to send to an escalation list so that a message is second to a second device if there is no response from the first device after a configurable time.

Acknowledgment

Operator units for acknowledgement

All alarms (alarms and faults, errors) must be acknowledgeable after issue of individual rights from all connected workstations. For tracking reason, a time stamp and assignment (based on user account) is required.

This includes:

- Local acknowledgement (control cabinet, automation station)
- Management level
- Remote operating equipment

Alarm management strategy

The software must permit configuration of alarm management strategy for each data point. The editor provide a way to edit data points directly, online via the building management system. The software for the user interface is also able to make batch changes to data point definitions and attributes to one or more data points selected by the user.

Alarm display

Color display

Incoming alarms must be colored for quick and easy interpretation. Both order and state as well as alarm priority must be recognizable. The alarm window must be displayed as per operator needs. Alarm window displays must be added to the bid.

Alarm message content

The message texts must contain all information necessary to allocate and resolve the error.

This includes at least the following attributes:

- Clear text.
- Control cabinet name
- Plant name
- Priority
- Timestamp
- Time.
- Status (acknowledged, unacknowledged).
- Instructions on how to resolve the problem must be available in the background.

Filter alarms

The building automation and control system must offer alarm filtering. Filtering must be possible by alarm lists or priorities. Alarms are displayed in popup windows. Stepby-step instructions on handling each alarm help the building automation and control system operator to find a solution.

Event management**Event routing and sorting**

Event messages can be displayed on each workstation in a table application and must include the following information: Name, value, event time and date, state, priority, acknowledge information, and alarm counter. The system must also be able to send out an acoustic message appropriate to the event category

Event message

Event messages can be displayed on each workstation in a table application and must include the following information on each event: Name, value, event time and date, state, priority, acknowledge information, and alarm counter. Each event must also be able to send out an acoustic message appropriate to the event category

Event acknowledgement

The user can acknowledge each event directly from the list, suppress the acoustic notification, print or delete it. The interface must also have an option to deleted active, acknowledged events until it is reset to the normal state. The user must be able to navigate to information associated with a data point, start an associated graphic or trended graphic diagram, or run a report for a data point selected directly from the event list.

Event treatment

The system must provide multiple alarm-handling options. These are to be configured in alignment the standard operating procedures.

Fast Treatment

The user must be able to acknowledge each event directly from the event list, suppress the acoustic notification, print or delete it. The interface must also have an option to deleted active, acknowledged events until it is reset to the normal state. The user must also be able to navigate to information associated with a data point, start an associated graphic or trended graphic diagram, or run a report for a data point selected directly from the event list.

Investigative Treatment

From the event list, operators shall have the ability to quickly focus on the source of the event, and all information (live and recorded video streams, recent history, schedules, and so on.) related to the event source.

Assisted Treatment with Operating Procedures

The system shall have the ability to program operating procedures consisting of a sequence of steps or actions, which the operator must perform. For each step of a procedure, the system shall provide instructions and operating tools. With appropriate permissions, a user shall have the ability to create, view, edit, or delete operating procedures. Each operating procedure shall be composed of steps - some of which may be mandatory - for the user to complete (for example, view the graphic of the object in alarm, view live and recorded video streams, or complete an event handling form) while some others shall have the ability to be configured to be executed automatically by the system (for

example, send emails to recipients or print on paper the information of the event).

Report generation

Reports

Must generation spontaneous or predefined reports to provide important plant data at any time. The reports must be printable and exportable as a PDF file. The data must be able to be edited in other programs (Microsoft Excel or Microsoft Access) for further analysis.

Standard report templates

Template to generate detailed reports at little effort. At least three different report templates must be available.

- Reports to record alarm and fault states
- Reports to record logbook entries
- Reports to record plant and control cabinet states.
- List of all current data points in an override state
- List of all disabled data points
- List of alarm strategy definitions
- Overall data point report
- Data point trend data listing
- Initial value report
- User activity report
- Event history report

Customized report templates

The system must permit generated, specific reports as well as individual report templates that may include graphics and trend views.

Remote operation

Operating options

User requirements on operation

The web-based user interface offers the same functionality as those on other workstations including operation and configuration. All user functions be available on clients via browser, installed client console, or Windows desktop App.

Via web browser

User must be able to remotely operate and engineer plants regardless of location. Of course, this openness cannot place the plant security at risk. The client must run on a browser as a full trust client application.

Dedicated Desktop Installed client

User must be able to remotely operate and engineer plants regardless of location. Of course, this openness cannot place the plant security at risk. The

client must operate as a fully installed software installation, locked with a desktop and prevents in this manner software from being minimized or hidden by other applications.

Windows Desktop APP

User must be able to remotely operate and engineer plants regardless of location. Of course, this openness cannot place the plant security at risk. An App must be loadable by the server PC on the client that operates like an installed application and is automatically updated as soon as new apps are available on the server.

Mobile App

An App, optimized for smart phones and tablets, must be available for the management. The App shall contain tools to see and command events as well as a System Browser to read and command all objects based on the security privileges of the operator as defined at the management station. The App shall be available for both Apple and Android operating systems.

Trend data

Analyses

Simultaneous, multiple trends

Multiple trend views must be possible simultaneously to provide a comprehensive plant overview. Standard plants from medium to higher complexity (as in this project) require a simultaneous display of up to 10 trend curves on the current page view to assess the plants. Multiple trend curves must thus be recorded at the same time.

Freely assign trend data

For greatest possible flexibility, operators must be able to assign and thus record max. 4 additional data points individually for each plant.

The assignment must be carried out from the management station.

Decentralized data storage

None of the trend data may be lost during communications failure to achieve gap-free trend documentation. For this reason, all trend data must be created and saved to the automation station. After communications are restored, all values saved on the management station must be updated automatically.

Record history data, trend

Vital data points and setpoints must be saved for each building services plant. The polling time is oriented to the signal type, i.e. analog values are recorded cyclically while digital or multistate values are recorded by event.

Intermediate storage of history data

Trend data are collected in the automation station and transferred to the management level after a specific time has expired or specific number of data

has been recorded. Trend data may not be lost if the management station is unavailable temporarily.

Trend comparison

The system must offer a time adjusted trend view to run analysis of changed conditions at various times.

2 CommunicationGeneral Interfaces

The building automation and control system must be extendible to ensure long-term operation and provide all standard interfaces commonly available on today's market.

Fire detection system, BACnet-based

BACnet-based fire detection systems supporting BACnet BIBB AE-LS-B as well as objects Life Safety Point and Life Safety Zone as per the PICS (Protocol Implementation Conformance Statement) document must be able to be integrated for best deployment of a building automation and control system. The following functions must be supported:

- Alarms and events from the fire detection system must be identified clearly and unambiguously.
- Signaling device states must be displayed as per the BACnet standard.
- Instruction texts must be able to be added to detectors and zones.
- Situational and floor plans as well as dynamic symbols must be used for visualization.
- A technical hierarchy, e.g. building, building part, zone, detector, must be provided to the operator for ease of operation.

Integrate third-party devices via OPC

The OPC Foundation must test and certify the system, which must be able to integrate and edit OPC data, and yet supply real time OPC data as an OPC server. System processing must include alarming, trend, scheduler, reporting, and be able to communicate with other devices.

The system must support the OPC specification:

- OPC data access

Integrate via IEC 61850

A native integration with an electrical power network via IEC 61850 protocol must be supported.

Integrate via Modbus

The management station must support communication to Modbus TCP/IP devices and sub systems directly from the management station.

Standard BACnet/ AMEV**DIN EN ISO 16484-5/ AMEV**

AMEV (Management station) AMEV Profile MBE-A and MBE-B

The management stations must meet AMEV profiles MBE-A and MBE-B as per AMEV guideline "BACnet 2011" V1.1.

B-A WS (management station)

The required management stations match the BACnet profile B-AWS (advanced management station) as per BTL Listing and ANSI/ ASHRE 135 guidelines. They must also support BACnet data points and BACnet personal safety security zone functionality. The BACnet protocol revision must be at least 13.

ONVIF video standard

The management system must be capable of video operations fully integrated into the same user interface with the following capabilities:

- Live video, Recording and Video Search and Replay
- Live video, Recording and Video Search and Replay
- Video display of multiple cameras
- Status and Commands
- PTZ and predefined PTZ Positions
- Remote Control of Video Monitors
- Video Events and Video Event Treatment including video tagging with alarm information
- Diagnostic information of Video Devices
- Video as Operating Procedure step

3 Operator Panel

Operator Panel definitions

Graphical plant operation via network-capable touch panel

The building management system is operated via a networked touch panel. They must inform the operator without log on using plant graphics on the present state of the plant.

Multiple plants must be able to be operated via the touch panel.

It must be capable of displaying and acknowledging alarms.

The operator should be informed about faults directly by a common alarm display via faults even when the display is switched off.

At the same time, functions to control the plant must be supported, so that plants must be able to be graphically operated and displayed using select data points, schedulers as well as trend views.

Integrated system component

The Touch panel must be part of an integrated solution, without external,

additional hardware required.

The Touch panel must be a BACnet standard device with a B-OD certification.

Various purposes

The supplier must be able to offer a wide range of different sizes and various versions as wall or control cabinet mounted devices.

Local plant operation

The system must provide scalable touch panels for control panel installation. The product range must include three different touch panel sizes between 7" to 15".

The touch panel must have a modern "state of the art" design, what means a capacitive touch screen supporting multi touch gestures, wide screen format and LED for status indications. The device must be powered by a 24V AC supply.

Local room operation

The system must provide scalable touch panels for room installation. The product range must include two different touch panel sizes between 10" to 15".

The touch panel must have a modern "state of the art" design, what means a capacitive touch screen, supporting multi touch gestures, wide screen format and LED for status indications.

To meet the room design requirements the touch panel must have aluminum frame and provides a wall mounting kit.

Power Supply

The touch panels must be protected against theft. The device must be powered either via Ethernet (PoE) or 24V AC supply.

3rd party device operation

To provide an open Platform the touch panel must also be able to operate and monitor 3rd party BACnet devices.

Remote access to the touch panel

Remote access to the touch panel must be available In order to support remote access to the touch panel via a browser, or any other end device, the touch panel must fully support HTML 5.0 standard.

Remote access to the building control system

Remote access to the touch panel must be available in order to support remote operation of the building automation control system, via standard devices with HTML 5.0 web browsers (e.g. Smart phones, tablets etc.)

User management

User management must be possible on the touch panel itself. The system admin don't need to use any other platform, all changes regarding user profiles can be managed on the panel itself.

User name and password is required to run functions that can change to plant settings in order to protect the plant. Authentication must be able to be disabled as an option.

Alarming

The system must be able to log and forward alarms to email recipients. Alarm forwarding must be priority wise and or time scheduled and individually assigned to multiple recipients.

To support fast alarm detection, the email subject line and the alarm message content must be configurable.

Trending

The touch panel must show predefined BACnet trends, running on automation stations.

It must be possible to display multiple trends, summarized in one chart.

The user must be supported to individually set up new trends on the device itself.

It must be possible to export trend data manually via a CSV file

It must be possible to export trend data automatically to an FTP server or email recipient, based on a pre-defined time schedule.

Local operator units must support temporary recording of trend data to allow local operators to record a trend at the control cabinet for diagnostic purposes.

Reports

The touch panel must support system wide status indications (such as manual switches, error messages, manual set point adjustments etc.)

The filter function must help to sort data points by alarm or BACnet object status and type.

Several export functions are required to export reports as a CSV file or to an FTP server or email recipient.

Heating curve

Graphical visualization and operating of the heating curve must be supported.

Plant graphics

The touch panel must provide the function that all plants and rooms can be visualized with graphics including animated 2D and or 3D symbols.

The user has the ability to modify the graphics on the device, online, via an embedded graphic editor, via a standard HTML 5.0 web browser.

The system must include a large library of symbols and graphic components to cover the most common applications.

Templates for primary plants, rooms, and dashboards shall be provided with the device.

List viewer

All BACnet objects and the properties of selected devices must be operated and monitored via an embedded list viewer function. The system must also support customized point lists.

4. Controllers

System description

General

Building automation and control system requirements

System requirements

General requirement including energy monitoring

Include a digital (DDC) building technology control system to operate technical equipment in buildings. The system must be able to carry out comprehensive measuring, control, optimization, and monitoring functions.

All systems deployed supply information on operating states and energy use to render current energy efficiency transparent or to display weaknesses. Measures can be made pursuant to this information that contributes to increased energy efficiency.

General requirement

Include a digital (DDC) building technology control system to operate technical equipment in buildings. The system must be able to carry out comprehensive measuring, control, optimization, and monitoring functions. The possibility for free programming of individual system components should be available to individually modify customer-specific requests.

User designation

The entire system (management, automation level including room automation) must be designed to define a clear, user designation UD encompassing 80 characters. The UD must be fully usable in the user programs on the management level. On the automation level as well, the UD must at a minimum be able to query details via local operating units.

Requirement for a project as per BACnet

Communications through the entire building automation and control system must be based on the BACnet standard valid at the time of the bidding.

Architecture

Three system levels

A building automation and control system featuring system architecture as per ISO EN 16484-3 is required. The three system levels must be interconnected via

communications.

- Management level
- Automation level (automation stations/individual room control)
- Field level (field device)

Automation stations

The system offered must provide largely decentralized intelligence to achieve high operational and plant availability. The devices are autonomous components that can independently execute assigned automation and control.

Implement third-party systems

Third-party systems must be able to be integrated on both management and automation levels to ensure full system consistency. Default interfaces must be provided. Third-party protocol implementation must be possible and require little effort. To do this, all hardware and software required for integration, all required services, clarifications with other technical and mechanical building installations, interface testing, data transmission testing, data point generation/integration as well as plant picture creation, backup, test protocol generation and specific documentation must be included in total costs.

Location-independent operation

The building automation and control system technology must allow for location independent operation and management of all messages and trends on all available types and views for the entire building automation and control system.

Consistency

Uniform system

The supplier must prove that the required functions originate from a single manufacturer and using one automation and control system, where the hardware and software are developed in a manner that allow for simply modification while operational for subsequent function extensions or changes.

Implement new data points

Building automation and control must be coherent to ensure possibility of future extensions and changes. This means that data points must be acquired once only, and then be provided automatically as needed to operator units and management level.

Integration of open standards

General

Implement via BACnet

Default protocols and suitable physical communications media must guarantee interoperability (ISO standard). Use only listed protocols and communications media. Third-party systems are integrated via BACnet. Provide only data required to efficiently and economically operate building services plants. BACnet communication, in compliance with the BACnet standard including B-BC

profile (Rev. 1.15)

Decentralized integration of communicating pumps

A decentralized interface module must allow for connecting communicating pumps to a BACnet-capable automation station. The automation station provides the following functions:

- Event-oriented communications
- Peer-to-peer (cross communication)
- Alarm and message processing, distribution to local operator units and building automation and control system.
- Scheduler with days of the week
- Calendar function
- Local trend recording in device buffer (long-term trend).

Electrical substations

Automation and control systems to monitor decentralized electrical installations are used in electrical substations. To this end, the most important information (messages/monitoring) from the existing systems (fire detection plants, doors, elevators, etc.) is activated for takeover.

All technical installations in the building are joined in one building automation and control system and operated and optimized via the management station. The building automation and control system as a whole enables the building operator to acquire and influence processes and their effects throughout the building.

Integrate fire detection systems

Fire detection system, BACnet-based

BACnet-based fire detection systems supporting BACnet BIBB AE-LS-B as well as objects

Life Safety Point and Life Safety Zone as per the PICS (Protocol Implementation Conformance Statement) document must be able to be integrated for best deployment of a building automation and control system. The following functions must be supported:

- Alarms and events from the fire detection system must be identified clearly and unambiguously.
- Signaling device states must be displayed as per the BACnet standard.
- Instruction texts must be able to be added to detectors and zones.

- Situational and floor plans as well as dynamic symbols must be used for visualization.
- A technical hierarchy, e.g. building, building part, zone, detector, must be provided to the operator for ease of operation.

Integrate Modbus devices

Integrate third-party devices via Modbus

Modbus-capable devices must be able to be connected to a BACnet-capable automation station for bidirectional data exchange. This connection must be direct via RS232 or RS485 interface and without conversion. The data points of the third-party system are mapped to input/output functions in BACnet and are then available as fully communicating data points for further processing and connection, e.g. for:

- Alarm handling and prioritization
- Override control, priority control and commands for central operation.
- Grouping
- Scheduler
- Trend recording

System must support the following Modbus properties:

- natively support Integration of Modbus devices via RTU and / or TCP
- Baud rate options of 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200
- integration of multiple Modbus RTU devices on the same trunk, even if the devices have different characteristics (e.g. baud rate, parity, stop bits)
- on-board bus termination, switchable with DIP switch
- on-board pull-up/pull-down resistances, switchable with DIP switch
- signed, unsigned, floats and double register data types
- support up to 64 bit big- and little-endian registers

Decentralized integration of third-party devices via Modbus

Modbus-capable devices must be able to be connected to a BACnet-capable automation station via decentralized interface module for bidirectional data exchange. The automation station provides the following functions:

- Event-oriented communication
- Peer-to-Peer (cross communication)
- Alarm and message processing, distribution to local operator units and building automation and control system.
- Scheduler program with weekdays
- Calendar function
- Local trend recording in device buffer (long-term trend).

Power failure

Automation station ' on board power back-up

Individual automation stations must have onboard power back-up provided via a super capacitor. Each DDC Controller shall be equipped with a battery-free

real-time clock. The intent is that if communications with the system controller is interrupted then the DDC Controller is still capable of using a default seven-day start/stop schedule.

Data backup

The data must be saved for extended periods of time in case of power failure or extensions or removal of automation stations.

The applications and all vital operating parameters (including setpoints, scheduler values, etc.) must not be lost due to a power outage. Other operating values such as alarms, trend data, etc. must be capable of being saved locally on the automation station.

Power restoration strategy based on backup power supply in case of power failure

Important and vital plant data including controls (automation station) must continue to run during power failure (switch-off via power switch or control fuse, etc.).

The backup power supply continues to provide power to the power portion as well as plant control including automation station. Power failure must be signaled via software, vital plants must continue to operate, non-vital plants and their aggregates and components must be switched to a safe operating mode or shut down immediately. After power returns, all automation stations and plants including their aggregates and components must start automatically. The various plants must be switched on and released at intervals to prevent switch-on peak loads. The current status for all switching and positioning commands, set points, manual interventions, etc. remains saved in the automation station and/or is reenabled following power restoration and used for the current operating mode.

Power restoration strategy in case of power failure

All plants and their aggregates and components as well as all automation stations fail during a power failure (switch-off via power switch or control fuse, etc.).

After power returns, all automation stations and plants including their aggregates and components must start automatically. The various plants must be switched on and released at intervals to prevent switch-on peak loads. The current status for all switching and positioning commands, setpoints, manual interventions, etc. remains saved in the automation station and/or is reenabled following power restoration and used for the current operating mode.

System time

General

System must support the maintenance of a real time clock up to 7 days.

Time synchronization in BACnet: Local time

The building automation and control system must have a uniform system time. To this end, a time master supporting BACnet BIBB DM-TS-A as per the PICS document must be defined. The time master must receive the DCF77, GPS or Internet NTP signal and provide it synchronized to all remaining system devices.

Time synchronization in BACnet: UTC time (coordinated universal time)

The building automation and control system must have a uniform system time. To this end, a time master supporting BACnet BIBB DM-UTC-A as per the PICS document must be defined. The time master must receive the DCF77, GPS or Internet NTP signal and provide it synchronized to all remaining system devices.

Subsystem autonomy

The automation stations must autonomously run their own time if the time master fails. The building automation and control time must be resynchronized automatically after the time master becomes available again.

Self monitoring and self diagnosis

Watchdog

The building automation and control system must monitor itself to always know its latest and current status. A watchdog function helps detect and signal failed system devices and restarts them in a defined mode.

Self diagnosis

Self diagnosis must be available to quickly detect errors. It must provide information on system function and load.

e.g. CPU and memory load must be displayed.

General plant operating states

Overview of operating modes

There are five higher operating modes for all plants: x Local emergency operation without automation station functionality (direct via I/O module or directly on the control cabinet as agreed to with owner).

- Local manual operation with automation station functionality (control panel in the control cabinet).
- Local - manual operation via visualization on the management level (all functions on the local automation station are set to Auto).
- Scheduler program under the condition that all plants are enabled for automatic operation.
- Automatic detection.

All control functions of the automation stations must be set to and remain on automatic for highest plant availability, if a plant or aggregate is switched to MANUAL. In individual cases, automatic mode must change over to this unit in case of redundancies when a plant or aggregate is switched off locally.

All safety and interlocking functions must take highest priority for operation independent of operating mode.

Automatic detection

The plants of the building automation and control system are switched on and off either automatic, or dependent on time or event. The following functions apply to the actual plant descriptions. All control loops, safety and interlocking functions must be guaranteed to work regardless of operating mode.

Controlled via scheduler program

All plants must be set to automatic for this operating mode. The plants of the building automation and control system must be switched on and off by individual use via a day, week, month, or annual scheduler program.

Manual operation

Different options are required for manual operation.

- Manual operation via management level (remote operation)
- Manual operation via local operator unit or laptop directly at the control cabinet.
- Manual operation via operator unit or directly at the control cabinet.

Manual operation generally is possible only if the corresponding automation station is running. Manual operation allows for manually overriding scheduled plant switchings. Plants switched off by schedule can be switched on via plant switching command. Manual control of the plant switching command is equal to automatic control, i.e. the scheduled control is retained for as long as the scheduler remains active.

Emergency operation

Local priority override takes place directly via the I/O modules. To this end, the I/O modules must have an integrated local override priority as per ISO 16484-2. All aggregates on the module must be able to be switched via this operation. To this end, the I/O modules must feature preselection switches Automatic - Manual as well as LED status displays or LCDs.

Valves, dampers, etc. must allow for continuous manual adaption. All interventions are signaled to the management station via automation station, and are then logged and visualized accordingly.

A manual operating level at the control cabinet must be included in the unit price if no integrated local priority override can be offered due to the system type.

Energy efficiency and references to applicable standards

General

The building is constructed under strict energy guidelines. The control technology deployed must contain all functions required to efficiently consume

energy.

Monitoring and evaluation

Automation level

Key performance indicators on the automation level

Monitoring and evaluation of measured values for primary plants (components and plant parts, software/program/system functions, setpoints, etc.) must occur directly on the automation level. Monitoring and evaluation is intended to recognize unfavorable operations of plants/components early on and thus lower or optimize energy consumption and wear and tear.

Monitoring and evaluating analog measured values

The following monitoring and evaluation must be able to be implemented for analog measured values (sensors, setpoint, modulating control of valves, dampers, variable speed drives, etc.):

- Determine the minimum value (lowest value) within a defined timeframe.
- Determine the maximum value (lowest value) within a defined timeframe.
- Determine the average value (lowest value) within a defined timeframe.
- Determine the linger period (in hours) during which the measured value moves between freely definable limit values.
- Determine deviation that the measured value deviated from the upper and lower setpoint within a defined timeframe.

The determined value is monitored to a minimum and maximum and displayed as quality state for breach and/or exceeding thereof. The value from the current timeframe is displayed; the value from the previous timeframe is also displayed and made available to the trend data. The evaluation ceases for a fault to the measured value (sensor interrupt, module fault, etc.), until the measured value once again assumes a reliable state. This fact must also be recognizable in the trend data.

Monitoring and evaluation of digital and multi-stage measured values

Digital measured values (messages, switching commands, operating modes, etc.) must be definable as key performance indicators and make possible the following evaluation and monitoring:

- Determine the runtime (operating hours) within a defined timeframe.
- Determine the switch-on frequency within a defined timeframe.
- Determine the runtime (operating hours) for each stage within a defined timeframe.
- Determine the switch-on frequency for each stage within a defined timeframe.

The determined value is monitored to a minimum and maximum and displayed as quality state for breach and/or exceeding thereof. The value from the current timeframe is displayed; the value from the previous timeframe is also displayed and made available to the trend data. The evaluation ceases for a fault to the measured value (sensor interrupt, module fault, etc.), until the value once again assumes a reliable state. This fact must also be recognizable in the trend data.

Monitoring and evaluating metered values

Metered values (consumption meters, pulse meters, etc.) must be definable as key performance indicators and make possible the following evaluation and monitoring:

- Determine the difference value (consumption value within a defined timeframe).

The determined value is monitored to a minimum and maximum and displayed as quality state for breach and/or exceeding thereof.

The value from the current timeframe is displayed; the value from the previous timeframe is also displayed and made available to the trend data. The evaluation ceases for a fault to the measured value (sensor interrupt, module fault, etc.), until the value once again assumes a reliable state. This fact must also be recognizable in the trend data.

Evaluation over different timeframes

Monitoring and evaluation must be able to occur over definable timeframes (annually, monthly, weekly, daily, hourly, 15-minutes).

Weighting of monitoring and evaluation criteria

Since an aggregate or component may include multiple evaluations, it is required to be able to weigh them so that they are included differently in the calculation of the resulting quality state.

Network security

Network hardware

In general

Automation hardware shall have built in standard security features, including:

- support firmware signature for verifying the integrity of installed firmware
- provide encrypted communication via HTTPS with the embedded web interface, incl. TLS/SSL certificates handling.
- ensure a password protection policy and the force of password change on the first use
- on board WLAN connection to be protected by WPA2

Specification and selection of required network devices

The supplier specifies and selects required network devices, required to build BACS network and interfaces to other networks as well as implementation of

specified IT security functions. All network devices must have the latest available firmware.

Engineering tools and engineering efficiency Engineering efficiency

System and tool platform

Creating solutions must be as efficient as possible, i.e. programming on construction sites; use of pre-defined application blocks, fast exchange of standard functions, etc. The goal is to achieve the maximum required level of flexibility at as little expense as possible.

Engineering tool must be freely distributed and license free software.

Preloaded application on devices

Applications portfolio

Prefabricated and tested must be loaded in a fix manner on the devices prior to commissioning. They can be used in the basic functions without the use of additional engineering tools.

Harmonized tools and workflows

Consistent tools

Uniform data and functions must be used by the building automation and control system in a consistent manner throughout all tools to achieve a high level of data consistency. In other words, all data is only entered once in the system. Consistent tool processes avoid a manual exchange of data (Import/Export).

One tool shall provide optimized workflow for both engineering and commissioning processes.

System must be freely programmable with resemblance to CEN standard 11312 using block programming

Transparency for customers

Data backup

A data backup concept must be presented that provides the current state of a project in a form that is useable and complete to the customer. It includes raw data from plants, applications, engineering data (e.g. DP, labeling, links, parameters), documentation.

Customer changes

The technical operator at the customer be able independently make simple changes to the project. Potential training proposals must be appended to the bid.

Corporate performance

Performance on bid

eu.bac system certification

The bid for building automation and control includes an filled out eu.bac system checklist. Providing a manufacturer-neutral eu.bac system checklist contributes to rendering building automation and control and its quality comparable to the user.

Automation level

Requirements on the automation level

General

Automation station standard

Automation stations must be intelligent. They must be autonomous. They must be built to go from high decentralization into small units (DDCC).

Automation stations must be freely programmable and feature graphical programming optimized for building automation and control. The following functions must be possible with it: Control, measure, signal at various priorities and by event, monitor, alarm, count, calculate, schedule, save trend values, and log as per DIN EN ISO 16484-

5. BACnet server (automation stations) certificates must be added to the bid.

Automation stations must have:

- an embedded WLAN interface conforming to IEEE 802.11b/g/n, operating in the frequency band 2.4....2.462 GHz, protected by WPA2,
- a 2-port Ethernet switch 10Base-T / 100Base-TX, IEEE 802.3 compatible
- a processor speed of at least 300MHz

Automation station I/O

Automation station must have both onboard I/O and the ability to expand via I/O modules. On board I/O must support the following signal types: x Passive sensors LG-Ni 1000, 2x LG-Ni1000, Pt 1000 (*75, 385) x NTC 10k, NTC 100k

- Resistance sensors 1000 Ohm, 2500 Ohm, 2650 Ohm, 1000...1175 Ohm (for setpoint shift)
- Active sensors DC 0 ... 10 V
- Current measurement analog DC 0...20 mA or 4...20 mA
- Binary potential-free contacts for signaling functions
- Counter to 25 Hz (electronic switch to 100 Hz)

- Analog outputs DC 0....10V
- Relay outputs for binary controls, changeover contact (NO, NC, pulse)

System design

Manufacturer must prove that they have various scalable automation stations to ensure optimal automation station design. Associated system documentation must be added to the bid and included in system evaluation. Documentation must show that the hardware (DDC and I/O modules) is designed optimally for the number of the required data points.

Delineation, automation to management level

All management level functions must be fully engineered in the automation station to increase plant availability. Delineation is defined to ensure that no additional engineering is required at the management level (BACnet client).

Delineation, room automation to management level

All management level functions must be fully engineered in the room automation station to increase plant availability. Delineation is defined to ensure that no additional engineering is required at the management level (BACnet client).

Operation concept at automation level Local operation

General

Local operation with access for the corresponding automation station, or network operation via BACnet to all or selected automation stations, or simple room operation must be available.

Operator and monitoring units

Operator Interface. Web server shall reside on high-speed network with building controllers. Each standard browser connected to server shall be able to access all system information using HTML5. In addition to the primary operator interface, the system shall include a secondary interface compatible with a locally available commercial wireless network and viewable on a commercially available wireless device such as a Wireless Access Protocol 3G/4G/LTE enabled cellular telephone or latest. This secondary interface may be text-based and shall provide a summary of complete site data. As a minimum, the following capabilities shall be provided through this interface:

Networkable operator and monitoring unit

Plant operation must be possible both locally and via management level. Local operation must be location-independent and allow for maintenance staff work from any automation station or be integrated in the control cabinet door.

Operation must allow for access to all values (current values, setpoints, parameters, maintenance and fault messages) without special engineering as well as plant-specific composition of vital values.

Operation must allow for graphic display of weekday and exception programs, heating curves and trends set up individually. Local operator units must support temporary recording of trend data to allow local operators to record a trend at the control cabinet for diagnostic purposes.

Graphical plant operation via network-capable touch panel

The building management system is operated via a networked touch panel. They must inform the operator without log on using plant graphics on the present state of the plant. Multiple plants must be able to be operate via touch panel. Is must be capable of displaying and acknowledging alarms. The operator should be informed about faults directly by a common alarm display via faults even when the display is switched off. At the same time, functions to control the plant must be supported, so that plants must be able to be graphically operated and displayed using select data points, schedulers as well as trend views. A capacitive display is used to operate. The touch panel as be added as an integral component of the overall system via a scalable web interface as well as a pleasant form of polished aluminum frames. User name and password is required to run functions that can change to plant settings in order to protect the plant. Authentication must be able to be disabled as an option.

Web operation independent of hardware

Operation must allow for graphic display of weekday and exception programs, heating curves and trends set up individually. Local operator units must support temporary recording of trend data to allow local operators to record a trend at the control cabinet for diagnostic purposes.

Operation via web browser or mobile clients

Vital functions must be viewable regardless of plant location. To this end, system must be accessible via standard HTML based browser, with ability to view all actual values and setpoints, plants and operating states.

Operator intervention via operator units

Plant operators must be able to switch via operator units the plant and individual aggregates and components and deactivate Auto mode via operator units. Read/write access rights must be considered in this regard.

Manual intervention signal

An alarm message must be generated following manual operator intervention as the plants are designed and controlled for highest possible energy efficiency.

Online trends

Local operator units must support temporary recording of trend data to allow local operators to record a trend at the control cabinet for diagnostic purposes.

Monitoring

Manual intervention (override), switching frequency

Monitoring, evaluation, and display of switching frequency is required for manual interventions over a defined timeframe. The determined value is monitored to a minimum and maximum and displayed as quality state for breach and/or exceeding thereof. The determined value from the current timeframe is displayed; the value from the previous timeframe is also displayed and made available to the trend data.

Manual intervention (override), runtime

Monitoring, evaluation, and display of runtime is required for manual interventions over a defined timeframe. The determined value is monitored to a minimum and maximum and displayed as quality state for breach and/or exceeding thereof. The determined value from the current timeframe is displayed; the value from the previous timeframe is also displayed and made available to the trend data.

I/O modules

General

Modular Expandability

The system shall employ a modular I/O design to allow easy expansion. Input and output capacity is to be provided through plug-in modules of various types. Controller with more than 2 IO module or total IO count more than 40 on one controller with modules shall not be acceptable. Adding more IO points on one controller shall impede the distributed architecture purpose and increase the operational complexities in case of controller failure.

Each IO Module shall be BACnet IP and BTL Certified, each module shall have 2 built in Ethernet ports

Construction

As highly flexible I/O modules are needed for complex and large technical equipment in buildings, they must be composed individually for each plant. To this end, modules must be configurable for various signal types, grouped, labeled per channel with clear text, two-sided readable, and distributed or set across several control cabinets/panels. Automation stations must allow for flexible expansion of I/O via these modules. The entire module electronics must be protected by a stable plastic housing against touch and soiling.

Diagnostic function

A status diagnosis for each channel is required to quickly locate installation or plant errors. The status is displayed by LED or on the module.

LED display

The color of the status LED must be configurable to correspond with message type to provide an easy overview in the control cabinet. Feedback: green, maintenance:

yellow, warning: red.

Remote I/O modules

Remote I/O modules must be able to be used for small plants or parts thereof to keep the size and number of control cabinets/panels as low as possible. The modules must be able to be as far as 200 m from the automation station. The maximum number of data points edited this way may only be limited by the maximum capacity of the automation station.

Isolating terminal functionality

The electronic modules must have isolating terminals to simplify hardware tests and commissioning. As a result, connected field devices can be measured at the test plug sockets without module electronics influence. At the same time, the connection terminals must act as cabinet/panel terminal strips. If the bidder cannot provide proof for this function, all inputs and outputs must be run via separate isolating terminals. The resulting costs must be included in the unit prices.

Local priority control

Level for manual local priority control

All module outputs must be able to be switched manually for fast and system independent local priority control. Operation must be possible and available for data point testing without software as soon as power is supplied to the module. The module must have an optical status message facility to avoid faulty positions.

Monitoring local priority control

The building automation and control system must be able to indicate any intervention via the local priority control. This indication must be well displayed at the management level.

Connection

Short-circuit proof

Field devices and motors must be connected directly without requiring coupling relays or other proprietary hardware. All terminals are protected against short circuit and incorrect wiring using AC/DC 24 V. Field device errors must be recognized and displayed reliably to retain high plant availability.

Broken wire interlock

Interlocks (hardware) and fault messages must be designed for possible wire breaks or loose terminals under closed-loop rules, i.e. the automation station then has status "1" OK (closed monitoring loop) or no fault, and status "0" (interrupted monitoring loop) or fault.

Connect field devices

Field device standards

The automation stations or I/O modules must support all common sensors (e.g. temperature, humidity) and actuators (valves, damper actuators) without requiring additional conversion hardware. The bidder must provide proof that the field devices used for the project were tested under the entire system and documented accordingly.

Use of I/O modules on the automation level

Functionality for the I/O system must be implemented on the automation level.

Updates and adaptations

Updates

Changes during operation

Customer-specific plant programs must allow for minor adjustments without having to switch off unrelated plants and without changing set parameters and setpoints.

Changes to applications during operation

Minor program changes must be able to be introduced without operational interruptions.

Adaptations

Access to system network

Operators must be able to enter adapted parameters, setpoints, times etc. in each automation station via the system network under their password.

Communication

Standard BACnet / AMEV

DIN EN ISO 16484-5 / AMEV

BACnet conformance and BTL logo

The BACnet servers (automation stations) used must support at least BACnet standard Version 1, Revision 15 (1.15) or higher.

B-B C (automation station)

Automation stations must match the BACnet Profile B-BC (Building Controller) as per the BTL Listing.

AMEV AS-A and AS-B (Automation station)

The automation stations must meet AMEV profiles AS-A and AS-B as per AMEV guideline "BACnet 2011" V1.1.

Conformance declaration

Protocol implementation, and conformance statement (PICS)

Manufacturer self-declaration PICS is required prior to executing work to gain information on the type of communication for the building automation and control system.

Communication via BACnet / IP

BACnet/IP(v4-v6) to BACnet/MS/TP

The automation station must be able to integrate, using a router manufactured in house, the MS/TP protocol via BACnet/IP.

BACnet/IP(v4-v6) to BACnet/MS/TP or BACnet/LonTalk

The automation station must be able to integrate, using a router manufactured by the same vendor, the BACnet/MS/TP protocol via BACnet/IP as well as BACnet/LonTalk.

BACnet/IPv4 to BACnet/IPv6

The building management system must be able to connected the BACnet/IPv4 protocol with BACnet/IPv6 protocol using a router manufactured by the same vendor.

BACnet LonTalk to BACnet MS/TP

The building management system must be able to connected the BACnet/LonTalk with BACnet/MS/TP protocol using a router manufactured by the same vendor.

Physical structure

Network structure

Structure

The offered network must be flexible and allow for all types of networks (line, star, ring, tree, etc.) to satisfy all owner/operator needs.

Building automation and control system - Automation stations

Openness

Integration of third-party systems

If possible, the same communication protocol must be used as for the existing technical equipment in the building to integrate third-party systems (refrigeration machines, lighting and building automation and control systems, etc.). Building automation and control systems not offering this integration as specified must include and clearly declare any additional conversion hardware (gateways) in their price.

Open and neutral communication via BACnet

Automation stations are connected to the management level via communication bus. System structure must allow open, neutral and manufacturer-independent communication. Communications must take place in principle via BACnet even if proprietary communications would be possible based on the automation stations used. Intermediate OPC servers are not allowed.

Automation station - Automation station

Standard protocol

Uniform protocol

Communication must also be standardized even between individual modules and automation stations. All devices must communicate on the same protocol on the entire room level.

Proposed System shall be equipped with DDC/ having capability to Connect directly with following Standard Industry Protocols as minimum.

- BACNet on IP
- MOD Bus
- Wireless communication
- DALI
- Ethernet

Automation station - Field level

Field device connection

Connect field devices

The automation stations or I/O modules must support all common sensors (e.g. temperature, humidity) and actuators (valves, damper actuators, lighting control, blinds drives) without requiring additional conversion hardware. The bidder must provide proof that the field devices used for the project were tested under the entire system and documented accordingly.

Connect communicating field devices

Common manufacturers must be integratable to connect third-party devices and subsystems. (e.g. communicating pumps, Modbus subsystems etc.).

Third-party system connection

A interface is required to connect various third-party devices that supports communication protocols such as Modbus

5. PORTABLE OPERATORS TERMINAL (POT)

1) POT shall be provided to allow operator readout of system variables, override control and adjustment of control parameters. The POT shall be portable and plug directly into individual controllers for power and data.

2) The minimum functionality of POT shall include :

- Set points to a fixed value or state.
- Display diagnostic results.
- Display sequentially all point summary and sequentially alarm summary.
- Display/change digital point state, analog point value.
- Display/change time and date.
- Display/change analog limits.
- Display/change time schedule.
- Display/change run time counts and run time limits.
- Display/change time and/or event initiation.
- Display/change programmable offset values.
- Access DDC initialization routines and diagnostics.
- Enable/disable points, initiators and programs.
- Display/change minimum ON/OFF and maximum OFF times.

3) The POT shall be complete with command keys, data entry keys, cursor control keys or liquid crystal display (LCD). Access shall be via self prompting menu selection with arrow key control of next menu/previous menu and step forward/backward within a given menu.

4) Connection of a POT to a controller shall not interrupt or interfere with normal network operation in any way, prevent alarms from being transmitted, or interfere with Control Station commands and system modifications.

5) Connection of POT at any controller shall provide display access to all controllers on that bus. In case the controller has a fixed LCD display and entry keyboard, then the display access shall be available on each screen.

6) It should be possible to override the commands given through POT by the Operator Control Station.

7) POT shall have touch screen color display and it shall possible to hook this to Local area Network so that the entire system data can be visualized.

8) POT shall have self learning capability so that it can recognize the DDCs on the network and update all points without any manual programming.

9) Plant operators must be able to switch via operator units the plant and individual aggregates and components and deactivate Auto mode via operator units. Read/write access rights must be considered in this regard.

6. FIELD DEVICES

ELECTRIC AND ELECTRONIC CONTROLS RELATED EQUIPMENT

General Requirements

All controls shall be capable of operating in ambient conditions varying between 0-55 deg. C and 90% R.H. non-condensing.

All Control devices shall have a 20 mm conduit knockout. Alternatively, they shall be supplied with adaptors for 20 mm conduit.

Ancillary Items

When items of equipment are installed in the situations listed below, the BAS contractor shall include the following ancillary items:

(i) Weather Protection

All devices required to be weatherproofed are detailed in the Schedule of Quantities. IP ratings for the equipment are mentioned in the respective section.

(ii) Pipework Immersion

Corrosion resisting pockets of a length suitable for the complete active length of the device, screwed ½" (13 mm) or ¾" (20 mm) NPT suitable for the temperature, pressure and medium.

(iii) Duct Mounting (Metal or Builders Work)

Mounting flanges, clamping bushes, couplings, locknuts, gaskets, brackets, sealing glands and any special fittings necessitated by the device.

TEMPERATURE SENSOR

Temperature sensors for space, pipes and ducts, shall be of the Resistance Temperature detector (RTD) type or thermistor. These shall be two wire type and shall conform to the following specifications :

- 1) Immersion sensors shall be high accuracy type with a high resistance versus temperature change. The accuracy shall be at least At $-30...130\text{ }^{\circ}\text{C}$: $\pm 1.3\text{ K}$.
- 2) Immersion sensors shall be provided with separate Brass thermo well. These shall be manufactured from bar stock with hydrostatic pressure rating of at least 10 kgf/cm^2 .
- 3) The connection to the pipe shall be screwed type. An aluminum sleeve shall be provided to ensure proper heat transfer from the well to the sensor. Terminations to be provided on the head. Flying leads shall not be acceptable.
- 4) The sensor housing shall plug into the base so that the same can be easily removed without disturbing the wiring connections.
- 5) Duct temperature sensors shall be with rigid stem and of averaging type. These shall be suitable for duct installation.
- 6) Outdoor air temperature sensor shall be provided with a sun shield.
- 7) The sensors shall not be mounted near any heat source such as windows, electrical appliances etc.

The temperature sensors may be of any of the following types :

- 1) PT 100, PT 1000, PT 3000
- 2) Thermistor

HUMIDITY SENSOR

Space and duct humidity sensors shall be of capacitance type with an effective sensing range of 10% to 90% RH. Accuracy shall be + 3% or better. Duct mounted humidity sensors shall be provided with a sampling chamber. Wall mounted sensors shall be provided with a housing. The sensor housing shall plug into the base so that the same can be easily removed without disturbing the wiring connections. The sensors shall not be mounted near any heat source such as windows, electrical appliances etc.

FLOW METER

Water flow meters shall be either Electromagnetic or ultra-sonic type. For electromagnetic flow meter, teflon lining with 316 SS electrodes must be provided. The housing shall have IP 55 protection. Vendors shall have to get their design/ selection approved by the Consultant, prior to the supply.

The exact ranges to be set shall be determined by the contractor at the time of commissioning. It should be possible to 'zero' the flow meter without any external instruments, with the overall accuracy of at least $\pm 2\%$ full scale.

PRESSURE TRANSMITTER FOR WATER

Pressure transmitters shall be piezo-electric type or diaphragm type. (Bourdon Tube type shall not be acceptable). Output shall be 4-20mA or 0-10V DC and the range as specified in the data sheet depending on the line pressure. Power supply shall be either 24 V AC, 24V DC or 230V AC. Connection shall be as per manufacturer's standards. The pressure detector shall be capable of withstanding a hydraulic test pressure of twice the working pressure. The set point shall fall within 40%-70% of the sensing range and detector shall have sensitivity such that change of 1.5% from the stabilized condition shall cause modulation of the corrective element. The sensor must be pressure compensated for a medium temperature of -10 o C to 60o C with ambient ranging between 0qC to 55qC.

DIFFERENTIAL PRESSURE SWITCH FOR PIPE WORK

These shall be used to measure pressure differential across suction and discharge of pumps. The range shall be as specified in the data sheet. Switch shall be ON with increase in differential. Housing for these shall be weather proof with IP 55 protection. The pressure switch shall be capable of withstanding a hydraulic test pressure of 1.5 times the working pressure. The set point shall fall in 40-70% of the scale range and shall have differentials adjustable over 10%-30% of the scale range. The switches shall be provided with site adjustable scale and with 1 NO/NC contacts.

DIFFERENTIAL PRESSURE SWITCH FOR AIR SYSTEMS

These shall be diaphragm operated. Switches shall be supplied with air connections permitting their use as static or differential pressure switches.

The switch shall be of differential pressure type complete with connecting tube and metal bends for connections to the duct. The housing shall be IP 54 rated. The pressure switches shall be available in minimum of 3 ranges suitable for applications like Air flow proving, dirty filter, etc. The set point shall be concealed type. The contact shall be SPDT type with 230 VAC, 1A rating.

The switch shall be supplied suitable for wall mounting on ducts. It should be mounted in such a way that the condensation flow out of the sensing tips. Proper adaptor shall be provided for the cables.

The set point shall fall within 40%-70% of the scale range and I has differentials adjustable over 10%-30% of the scale range. The switches shall be provided with site adjustable scale and with 1 NO/NC contacts.

AIR FLOW SWITCHES

Air flow switches shall be selected for the correct air velocity, duct size and

mounting attitude. If any special atmospheric conditions are detailed in the Schedule the parts of the switches shall be suitably coated or made to withstand such conditions. These shall be suitable for mounting in any plane. Output shall be 1 NO/NC potential free. Site adjustable scale shall also be provided.

AIR PRESSURE SENSOR

The pressure sensor shall be differential type. The construction shall be spring loaded diaphragm type. The movement of the membrane in relation to the pressure should be converted by an inductive electromagnet coupling which would give an output suitable for the controller. The pressure sensor shall be in a housing having IP 54 ratings in accordance with IEC 529. Suitable mounting arrangement shall be available on the sensor. The sensor shall come complete with the PVC tubes & probes.

WATER FLOW SWITCH

These shall be paddle type and suitable for the type of liquid flowing in the line. Output shall be 1NO/1NC potential free.

CO SENSOR

CO Sensor shall be integrated Surface mounted type on the field. These shall work on 24V AC/DC supply with the output being standard type i.e. 4-20 mA / 0- 10 Volts etc. Response time of the detector shall be <10 minutes

AIR VELOCITY SENSOR

Air Velocity Sensor shall be integrated Surface / Duct mounted type on the field. These shall work on 24V AC/DC supply with +/- 10% variation the output being standard type i.e. 4-20 mA / 0- 10 Volts etc. with an accuracy of +/- 3%. It shall be possible to select the different ranges by changing the jumpers on the sensor. At least 3 selection ranges on the sensors are required.

CO2 SENSOR ' Duct Type

CO2 Sensor shall be wall / Surface mounted type on the field. These shall work on 24V AC/DC supply with the output being standard type i.e. 4-20 mA / 0- 10 Volts etc. The sensing range required shall be 0-2000 PPM with good resolution.

The preferred type of sensing element / method is NDIR type with accuracy of +/-50PPM or +/-2 % of measured value. Time constant of sensor shall be <5 minutes.

LEVEL SWITCH

The level switches shall have to meet the following requirement:

Type	Float Type/Capacitance type/Conductivity type
Mounting	To suit application.
Connection	Flanged ANSI 150 lbs RF Carbon steel
Float material	316 SS
Stem Material	316 SS
Output :	1 NO, 1 NC potential free
Switch Enclosure	IP 55

LEVEL TRANSMITTER**Description :**

Level Transmitter to be an ultrasonic non-contacting level meter which will increase the effectiveness of your liquid management process. It is designed its sensor and controller in one compact housing. L.T. is two-wire loop-powered instrument and its measurement range is 5 meters. menu makes the user easy and simple for calibration. All functions are optimized which enables you to effectively monitor the liquid level and keep your facilities running safely and reliably.

Principle of Operation :

The sensor transmits ultrasonic pulses to the measurement target. The pulses are reflected from the surface of the target and received back by the sensor.

The running time is converted in to the distance and it shows as level or volume on the display.

Measurement Type	Ultrasonic non-contacting
Measuring Range	5m/10m/15m/20m/30m/40m/50m/60m/70m/
Accuracy	0.25F.S, 0.5%F.S, 1%F.S
Resolution	3mm or 0.1% of F.S
Output Analog	4-20mA-2wire[load Resistance=510Ω] 4-20mA-4wire[load Resistance=250Ω]
Output option	RS485, Relay/Alarm
Power Supply	24VDC, 220VAC+/-10% option
Display	LCD, 4-digit
Display Units	mm, cm, m
Dead Band	25cm[min.]
Process Temp.	-20~+70°C(Sensor), -20~+60°C(LCD)
Temp. Comp	-20~+60°C
Pressure	<1bar
Protection Class	IP65
Process Mount	Screwing with thread M48x2 / M60x2 / M78x2/G2 or Flange
Relay/Alarm Output(option)	Alarm for high and low level AC 250V/8A or DC 30V/5A
Weight	~3kg(not include cable)

a. ENCLOSURES FOR CONTROLLERS AND ELECTRICAL PANELS

All the controllers shall be housed in Lockable Vandal proof boxes which shall either be floor mounted or wall mounted. These shall be free standing, totally enclosed, dust and vermin proof and suitable for tropical climatic conditions.

The panel shall be metal enclosed 18 SWG CRCA sheet steel cubicle with gaskets between all adjacent units and beneath all covers to render the joints dust proof. All doors and covers shall be hinged and latched and shall be folded and braced as necessary to provide a rigid support. Joints of any kind in sheet metal shall be seam welded with welding slag grounded off and welding pits wiped smooth with plumber metal.

All panels and covers shall be properly fitted and secured with the frame and holes in the panels correctly positioned. Fixing screws shall enter into holes tapped into an adequate thickness of metal or provided with nuts. Self-threading screws shall not be used in the construction of control panels. Knockout holes of approved size and number shall be provided in the panels in conformity with the location of incoming and outgoing conduits/ cables. Lamps shall be provided to support the weight of the cables. The dimension of the boxes shall depend on the requirement with the colour decided in consultation with the Architect/ Consultant.

Note: All panel enclosures used in plant room spaces and external to building shall be suitable for outdoor application (IP 54 protection).

b. CONDUITS AND WIRING

Prior to laying and fixing of conduits, the contractor shall carefully examine the drawings indicating the layout, satisfy himself about the sufficiency of number and sizes of conduits, sizes and location of conduits and other relevant details. Any discrepancy found in the drawings shall be brought to the notice of Architect/ Engineers any modifications suggested by the Contractor shall be got approved by the Architect/ Engineers before the actual laying of conduits is commenced.

c. CONDUITS/TRUNKER

Conduits and accessories shall conform to relevant Indian Standards. PVC conduits of required dia shall be used as called for in the schedule of quantities. Joints between conduits and accessories shall be securely made, with help of adhesive.

The conduits shall be delivered to the site of construction in original bundles and each length of conduit shall bear the label of the manufacturer.

d. CONNECTIONS

All jointing methods shall be subject to the approval of the Architect/Engineer. Separate conduits shall run for all power wiring.

The threads and sockets shall be free from grease and oil. Connections between conduit and controller metal boxes shall be by means of brass hexagon smooth bore bush, fixed inside the box and connected through a coupler to the conduit. The joints in conduits shall be smooth to avoid damage to insulation of conductors while pulling them through the conduits.

e. BENDS IN CONDUIT

Where necessary, bends or diversions may be achieved by means of bends and/or circular inspection boxes with adequate and suitable inlet and outlet screwed joints. In case of recessed system each junction box shall be provided with a cover properly secured and flush with a finished wall surface. No bends shall have radius less than $2\frac{1}{2}$ times the outside diameter of the conduit.

f. FIXING CONDUITS

The conduits, junction boxes, outlet boxes and controller boxes once installed in position, shall have their outlets properly plugged or covered so that water, mortar, insects or any other foreign matter does not enter into the conduit system. Surface conduits shall be fixed by means of spacer bar saddles at intervals not more than 500 mm.

The saddles shall be 2 mm x 19 mm galvanized steel flat, properly treated, primer coated & painted, securely fixed to supports by means of nuts and bolts/rawl bolts and brass machines screws.

g. DRAWING OF CONDUCTORS

While drawing insulated wires/cable into the conduits, care shall be taken to avoid scratches and kinks which may cause breakage of conductors. No joint shall be allowed in case of breakage of any conductor. No joint shall be shaved off like length of the conductors. Insulation shall be shaved off like sharpening of a pencil and it shall not be removed by cutting it square to avoid depression/cutting of conducting material.

Strands of wires shall not be cut to accommodate & connect to the terminals. Terminals shall have sufficient cross-sectional area to take all the strands.

No wire shall be drawn into any conduit until all work of any nature that may cause injury to wire is completed. Before the wires are drawn into the conduit, the conduits shall be thoroughly cleaned of moisture, dust, dirt or any other obstruction. Where wires are connected to detectors, or panel, sufficient extra length of wires shall be provided to facilitate easy connections and maintenance.

Only licensed supervisors/wiremen shall be employed for cabling and other connected work. Only approved make of cables shall be used. The cables shall be brought to the site in original packing.

h. SIGNAL CABLING & COMMUNICATION CABLING

The signal cable shall be of the following specifications:

- | | | | |
|----|-------------------|---|---|
| a. | Wire | : | Annealed Tinned Copper |
| b. | Size | : | 1.0 sq. mm, stranded type |
| c. | No. of conductors | : | Two (One pair) |
| d. | Shielding | : | Overall beld foil Aluminium polyester shield. |
| e. | Jacket | : | Chrome PVC |
| f. | Nominal DCR | : | 17.6 ohm/km for conductor
57.0 ohm/km for shield |

- g. Nominal capacitance: 130 pF/m between conductors at 1 KHz
180 pF/m between one conductor
and other Conductors connected to
shield.

i. **LOCAL AREA NETWORK CABLE**

Depending on the type of LAN system being used by the contractor, standard, manufacturer's specification shall apply.

j. **BMS DELIVERABLES-**

The deliverables expected from the BMS is broadly defined here under. However it is understood that the I/O summary detailed in this specifications will be reckoned while designing the system

Electrical monitoring and data logging:

Parameters relevant to Automatic Transfer Switches (ATS) at the origin of utility supply and standby sources and Multi Data Meters (MDM) in outgoing feeders as per following.

(Through integration as all MDMs shall be provided with communication ports)

Data Points to be monitored & trended for MDMs: kW, kWh, kV Ar.p.f, V, A, Power outages, DG run

Data Points to be monitored & trended for KWH Meters: kW, kWh

k. **3rd Party System Integrator Units:**

A. The 3rd party Integration unit shall provide the interface between Ethernet LAN and the 3rd party field control devices such as DDC or PLC or any other devices which need to be integrated. These shall also provide supervisory capability of functions over the devices connected to it. **The purpose of using these units should be limited to integrate devices only, not for any DDC interface with GUI, provided by others.**

A. The Unit must provide the following hardware features as a minimum:

- a. One no. on board RS-232 port
- b. One No. on Board RS-485 port
- c. Provision to include / add additional communication card
- d. Battery Backup
- e. Minimum RAM of 64MB SDRAM / 32MB FLASH (96MB total)

B. The Integration unit shall have built in drivers for open protocol such as

- a. Modbus over 485
- b. Mbus Serial
- c. KNX

If the above drivers are add-on products, it shall be made available/ considered while selecting the unit & the same to be confirmed in writing.

- C. The Integration unit should have inbuilt memory for program storage.
- D. The Integration unit should automatically backup its database for the user defined interval.
- E. All units shall have LEDs for fault / status identification such as
 - a. LAN active (one per port in case of multiport units)
 - b. LED to display proper functionality / Status of the unit.
 - c. LED to display healthiness of CPU of the unit

<u>BUILDING MANAGEMENT SYSTEM - IO</u> <u>POINT SUMMARY</u>	
S.No.	Description
1	Chillers
1	Chiller Start/Stop Command
2	Chiller Run Status
3	Chiller Trip Status
4	Chiller Auto/Manual status
5	Screw Chiller Software Integration
6	VFD Software Integration
7	Chiller Base Temperature S.P Enabled
8	Chiller Base C temperature Reset
9	Chiller Outlet Water Temperature
10	Common Supply Header Water Temperature
11	Common Return Header Water Temperature
14	Chiller isolation Motorised valves On/Off command & status
16	Chiller Flow Measurement
17	By Pass Valve Modulation and Feedback
	CHW Primary Pump
18	CHW Primary Pumps Start/Stop Command
19	CHW Primary Pumps Run Status
20	CHW Primary Pumps Auto/Manual status
	CHW Secondary Pumps
21	CHW Secondary Pumps Run Status
22	VFD Software Integration
	Chiller for Winter Cooling
26	Chiller Start/Stop Command

27	Chiller Run Status
28	Chiller Trip Status
29	Chiller Auto/Manual status
30	Common Supply Header Water Temperature
31	Common Return Header Water Temperature
	CHW Primary Pumps(winter cooling)
32	CHW Primary Pumps Start/Stop Command
33	CHW Primary Pumps Run Status
34	CHW Primary Pumps Auto/Manual status
35	Outdoor Temperature and Rh sensor
	Expansion Tank
36	Chilled Water Tank- Water Low High level Alarm
	Sub-Total I/O Point
2	Floor & Ceiling Mounted AHU's with cooling
1	AHU Supply Fan On/Off command
2	AHU Supply Fan On/Off status
3	AHU Supply Fan Auto/Manual status
4	AHU Supply Fans VFD speed feedback
5	VFD Software Integration
6	Return Air Temperature & Humidity input
7	AHU Filter status
	Sub-Total I/O Point
3	Floor Mounted & Ceiling AHU's
1	AHU Supply Fan On/Off command
2	AHU Supply Fan On/Off status
3	AHU Supply Fan Auto/Manual status
4	Room Temperature input
5	AHU Filter status
	Sub-Total I/O Point
4	TFA's Floor & Ceiling Mounted
1	TFA Supply Fan On/Off command
2	TFA Supply Fan On/Off status
3	TFA Supply Fan Auto/Manual status
4	Supply Air Temperature
5	TFA Pre-Filter status
	Sub-Total I/O Point
5	Splits

1	UPS Room Temperature
	Sub-Total I/O Point
6	Basement Ventilation
	Supply Air Ventilation
1	Axial Flow Fan On/Off command
2	Axial Flow Fan On/Off status
3	Axial Flow Fan Auto/Manual status
	Exhaust Air Ventilation
4	Axial Flow Fan On/Off command
5	Axial Flow Fan On/Off status
6	Axial Flow Fan Auto/Manual status
	Sub-Total I/O Point
7	Air Washer & Scrubber
	Air Washer
1	AW Fan On/Off command
2	AW Fan On/Off status
3	AW Flow Fan Auto/Manual status
4	Water Circulation Pump On/Off command
5	Water Circulation Pump On/Off status
6	Water Circulation Pump Auto/Manual status
	Scrubber
7	Scrubber Fan On/Off command
8	Scrubber Fan run status
9	Scrubber FAN Auto/Manual status
	Sub-Total I/O Point
8	Supply & Exhaust Fan Sections
	Supply Air Fan Section
1	SA Fan On/Off command
2	SA Fan On/Off status
3	SA Flow Fan Auto/Manual status
	Sub-Total I/O Point
9	Duct In-Line Fan
1	In-Line Fan On/Off command
2	In-Line Fan On/Off status
3	In-Line Fan Auto/Manual status
	Exhaust Air Fan Section
4	E.A Fan On/Off command
5	E.A Fan VFD run status

6	E.A FAN Auto/Manual status
	Sub-Total I/O Point
1	MAIN HYDRANT Line Pressure
2	Sprinkler Line Pressure
3	Hydrant & Sprinkler Riser Line Pressure
4	Elec Driven Main Fire Pump Run Status
5	Diesel Driven Main Fire Pump Run Status
6	DG Set Battery Voltage
7	Day Fuel Oil Storage Tank Low Level
8	Day Fuel Oil Storage Tank High Level
9	Elec Driven Press. Pump (Jockey Pump) Run Status
10	Fire Pump for Water Curtains Run Status
	Sub-Total I/O Point
1	Flushing Pump Run Status
2	Domestic Pump Run Status
3	RO Water Pump Run Status
4	Soft Water Supply pump Run Status
5	Pumps for boosting water supply from UG Flushing water tank for Garden Hydrant System
6	Storm Water Drainage Pumps
7	Basement Drainage Pumps
8	Sewer/Kitchen Sumps
9	Raw Water Pump Run status
10	Domestic Supply Filter Feed Water Pump Run status
11	Domestic Supply Multi-grade Sand Filter Pump Run status
12	Water Softener Soft Water Pump Run status
13	UG , Over head Water Tank Level
14	Raw Water, Treated Water etc. PH Level
15	Raw Water, Treated Water etc. conductivity Level
16	Basement Sump Pump Run Status
	Sub-Total I/O Point
1	Equalization Tank Level
2	Equalization Tank Pump Start/Stop
3	Equalization Tank Pump Flow Status
4	Equalization Tank Pump Run Status
5	Aeration Tank Blower Start/Stop
6	Aeration Tank Blower Run Status
7	Aeration Tank Blower Trip Status

8	Sludge holding tank Level
9	Sludge holding tank Pump Start/Stop
10	Sludge holding tank Pump Flow Status
11	Sludge holding tank Pump Run Status
12	MBBR Suction Pump Start/Stop
13	MBBR Suction Pump Flow Status
14	MBBR Suction Pump Run Status
15	Treated water tank Level
16	pH in Clarified water sump
17	Chemical Cleaning Pump Start/Stop
18	Chemical Cleaning Pump Run Status
19	Chemical Cleaning Pump Trip Status
20	Treated water tank Level
21	Treated water tank Pump Start/Stop
22	Treated water tank Pump Flow Status
23	Treated water tank Pump Run Status
24	Waste water overflow Pump Start/Stop
25	Waste water overflow Pump Flow Status
26	Waste water overflow Pump Run Status
27	Main incoming power supply
28	pH Monitoring of water before tertiary treatment
29	pH Monitoring of water after tertiary treatment
30	Treated Water Flow Metering
31	Conductivity Monitoring of water before treatment
32	Conductivity Monitoring of water after treatment
33	Chlorine Dosing Pump Start/Stop
34	Chlorine Dosing Pump Flow Status
35	Chlorine Dosing Pump Run Status
	Sub-Total I/O Point
1	DDC for Electrical Breakers - Outdoor HT Panels
	Incoming VCB Breakers
1	Incoming Breaker ON/OFF status
2	Incoming Breaker Trip status
3	Multifunction meter with RS485 showing V, A, PF, KVA , KW, KWH etc.
	Outgoing Breakers VCB
4	Outgoing Breaker ON/OFF status
5	Outgoing Breaker Trip status
6	Multifunction meter with RS485 showing V, A, PF, KVA , KW, KWH etc.
2	LT Panel Bus Bar
7	Incoming Breaker ON/OFF status
8	Incoming Breaker Trip status
9	Multifunction meter with RS485 showing V, A, PF, KVA , KW, KWH etc.

3	OUTGOINGS: (Bus Bar-1)
10	Incoming Breaker ON/OFF status
11	Incoming Breaker Trip status
4	OUTGOINGS: (Bus BAR -2)
12	Incoming Breaker ON/OFF status
13	Incoming Breaker Trip status
5	Street lights
14	Outdoor Lux Level
15	Street Lights Time Schedule
	Sub-Total I/O Point
6	DG's Day Tank Level
1	DG Set Battery Voltage
2	Day Fuel Oil Storage Tank Low Level
3	Day Fuel Oil Storage Tank High Level
4	ACB on/off status
5	Signal to Hooter cum strobe to indicate Low/High level in all the above tanks
	Sub-Total I/O Point
7	Lifts
1	Lift Run Status
2	Lift Alarm Status
	Sub-Total I/O Point

SOFTWARE INTEGRATION	
Sl. no.	Description
1	Water Cooled chilling machines
2	Variable Secondary Pumps Logic Controller and Secondary Pumps VFD
3	Cooling Tower (VFD)
4	AHU VFDs
5	Intelligent multifunction digital panel meters for Floor Panels
6	Intelligent multifunction digital panel meters for Main Breakers
7	Transformer & DG set
8	UPS
9	Lifts & Escalators Monitoring
10	Sewage Treatment Plant
11	Fire Alarm System
12	PA System
13	FIDS
14	PBB and AVDGS
15	Baggage Handling System

LIST OF ABBREVIATIONS

Followings List of Abbreviations shall have been used in preparing the Tender Specifications, Bill of Quantities & Drawings.

AABC :	AMERICAN AIR BALANCING COUNCIL
ACH :	AIR CHANGE PER HOUR
AC :	AIR CONDITIONING
ACMV :	AIR CONDUCTING AND MECHANICAL VENTILATION
AHU :	AIR HANDLING UNIT
ANSI :	AMERICAN NATIONAL STANDARD INSTITUTE
ARI :	AMERICAN REFRIGERATION INSTITUTE
ASHRAE :	AMERICAN SOCIETY OF HEATING, REFRIGERATION AND AIRCONDITIONING ENGINEER
ASME :	AMERICAN SOCIETY OF MECHANICAL ENGINEERS
ASTA :	ASSOC. CIATION OF SHORT - CIRCUIT TESTING AUTHORITIES
ASTM :	AMERICAN SOCIETY OF TESTING AND MATERIALS
ATG :	AIR TRANSFER GRILLE
AWS :	AMERICAN WELDING SOCIETY
BAS :	BUILDING AUTOMATION SYSTEM
BIS :	BUREAU OF INDIAN STANDARD
BMS :	BUILDING MANAGEMENT SYSTEM
BTU :	BRITISH THERMAL UNIT
CDW :	CONDENSER WATER
CFM :	CUBIC FEET PER MINUTE
CHW :	CHILLED WATER
CMS :	CENTRAL MONITORING SYSTEM
CRCA :	COLD ROLLED COLD ANNEALED
CSA :	CANADIAN STANDARD ASSOC. CIATION
CT :	COOLING TOWER
CTI :	COOLING TOWER INSTITUTE
DB :	DISTRIBUTION BOARD
DDC :	DIRECT DIGITAL CONTROLLER
DOL :	DIRECT ON LINE
DFA :	DELHI FIRE AUTHORITY
DIA :	DIAMETER

DIDW :	DOUBLE INLET DOUBLE WIDTH
DX	DIRECT EXPANSION
EA :	EXHAUST AIR
EEPROM :	ELECTRICAL ERASABLE PROGRAM
ELCB :	EARTH LEKAGE CIRCUIT BREAKER
ETL :	ELETRICAL TESTING LABORATORIES
EPA :	ENVIRONMENTAL PROTECTION ACT
FCU :	FAN COIL UNIT
F/A :	FLOOR ABOVE
F/B :	FLOOR BLOW
FCC :	FIRE COMMAND CENTRE
FD :	FIRE DAMPER
FFL :	FINISHED FLOOR LEVEL
FPM :	FEET PER MINUTE
FPS :	FOOT PER SECOND
FRP :	FIBERGLASS REINFORCED PLASTIC
GI :	GALVANISED IRON
GPM :	GALLON PER MINUTE
GSS :	GALVANIZED STEEL SHEET
H/L :	HIGH LEVEL
HDG :	HOT DIP GALVANIZED
HDPE :	HIGH DENSITY POLY ETHANE
HFC :	HYDRO FLURO CARBON
HP :	HORSE POWER
HVAC :	HEATING, VENTILATION & AIR CONDITIONING
IAQ :	INDOOR AIR QUALITY
IEC :	INTERNATIONAL ELECTROCHEMICAL COMMISSION
IKW :	INDICATED KILO WATT
IPD :	INITIAL PRESSURE DROP
ISO :	INTERNATIONAL STANDARD ORGANIZATION
KW :	KILO WATT
L :	LITRE
LCD :	LIQUID CRYSTAL DISPLAY
L/L :	LOW LEVEL
L/S :	LITRE PER SECOND
LSZH :	LOW SMOKE ZERO HALOGEN

LT	:	LOW TENSION
L	:	METER
MAX.	:	MAXIMUM
MCB	:	MINIATURE CIRCUIT BREAKER
MCC	:	MOTOR CONTROL CENTRE
MFD	:	MOTORIZED FIRE DAMPER
MIN	:	MINIMUM
MM	:	MILLIMETER
NBC	:	NATIONAL BUILDING CODE
NC	:	NOISE CRITERIA
NEC	:	NATIONAL ELECTRIC CODE
NFPA	:	NATIONAL FIRE PROTECTION ASSOC. CIATION
NPLV	:	NET PART LOAD VALUE
NIST	:	NATIONAL INSTITUTE OF STANDARDS & TECHNOLOGY
NEMA	:	NATIONAL ELECTRICAL MANUFACTURERS ASSOC. CIATION
NPSH	:	NET POSITIVE SUCTION HEAD
NTS	:	NOT TO SCALE
OA	:	OUTDOOR AIR
PHE	:	PUBLIC HEALTH ENGINEERING
PLC	:	PROGRAMMABLE LOGIC CONTROLLER
P.C.	:	PERSONAL COMPUTER
PSIG	:	POUNDS PER SQUARE INCH GAUGE
PUF	:	POLYURETHANE FOAM
RA	:	RETURN AIR
RAD	:	RETURN AIR DUCT
RCC	:	REINFORCED CEMENT CONCRETE
RH	:	RELATIVE HUMIDITY
RPM	:	REVOLUTIONS PER MINUTE
SA	:	SUPPLY AIR
SAD	:	SUPPLY AIR DUCT
SMACNA:		SHEET METAL & AIR CONDITIONING CONTRACTORS NATIONAL ASSOC. CIATION INC
STD	:	STANDARD
T/A	:	TO ABOVE
TAB	:	TESTING, ADJUSTING AND BALANCING
T/B	:	TO BELOW

TCC		TERMINAL CONTROL CENTRE
TFA	:	TREATED FRESH AIR
TOA	:	TREATED OUTDOOR AIR
TP	:	THREE PHASE
TR	:	TONS OF REFRIGERATION
TVOC	:	TOTAL VOLATILE ORGANIC COMPOUNDS
VAV	:	VARIABLE AIR VOLUME
VFD	:	VARIABLE FREQUENCY DRIVES
VIP	:	VIBRATION ISOLATING PAD
VSPS	:	VARIABLE SPEED PUMPING SYSTEM
XLPE	:	CROSS -LINKED POLYETHYLENE
SISW	:	SINGLE INLET SINGLE WIDTH
UL	:	UNDERWRITERS LABORATORIES INC.
WG	:	WATER GAUGE

BBB ✕ RRR

LIST OF BUREAU OF INDIAN STANDARD CODES

IS 1239 (Part– I) 1979	Mild Steel Tube
IS 1239 (Part – I) 1982	Mild Steel Tubular and Other Wrought Steel Pipe Fittings
IS 4736 – 1986 (Reaffirmed)	Hot Dip Zinc Coatings of Steel Tubes
IS 823-1964	Code of Procedure For Manual Metal Arc Welding o Mild Steel
IS 780-1984	Service Valves For Water Works Purpose
IS 778-1980	Copper Alloy Gate, Globe and Check Valves Fo Water Works Purpose
IS 1536-1976	Flanges Configuration
IS 5312 (Part –I) 1984	Swing Check Type Reflux Non Return Valves Fo Water Works
IS 2379-1963	Color Code For Identification of Pipelines
IS 554-1975	Dimension For Pipe Thread Where Pressure Tigh Joints Are Required On Threads
IS 655-1963 (Reaffirmed 1991)	Metal Air Ducts
IS 277-1992	Galvanized Steel Sheet For Fencing
IS 4064 Part II-1978	Specific Requirements For Direct Switches o Individual Motors
IS 3854-1969	Switches For Domestic & Similar Purpose
IS 732 (Part III-1902)	Inspection and Testing of Installation
IS 659 – 1964 (Reaffirmed 1991)	Air Conditioning Safety Code
IS 660 – 1963 (Reaffirmed 1991)	Mechanical Refrigeration (Safety Code)
IS 4894 – 1991	Test Code For Centrifugal Fan
IS 3103 –1975 Reaffirmed 1994	Code of Practice For Industrial Ventilation
IS 7240 – 1981	Application &Finishing of Thermal Insulation Material
IS 325	Specifications For Three Phase Induction Motor
IS 3142 – 1993	V Grooved Pulley
BS-EN-779 – 1993	Particulate Air Filters For General Ventilation
IS 702 – 1988	Industrial Bitumen
IS 8183 – 1993	Bonded Mineral Wool
IS 2494 – 1993	V Belts For Industrial Purposes
IS 2062 – 1992	General Purpose Steel

ASHRAE Hand Books	American society of heating, refrigeration and ai conditioning books - Applications 1999 - Fundamentals 1997 -System and equipments 1996 - Indoor air quality 62 – 1999
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ELEVATORS (LIFTS)

8.1 TRACTION ELEVATORS / LIFTS:

TRACTION ELEVATORS / LIFTS:

This section provides the technical requirement of Electric Traction Type Machine Room Less Glass (Scenic)/ Stainless steel Passenger Elevators, their components, safety devices, etc. All features shall be according to the standards/ codes listed below. The contractor shall be responsible to check and ensure dimensions of hoist ways before manufacturing, the requirements of statutory laws and local codes of Electrical / Elevators inspector and the equipment offered are suitable for the space available.

1.0 STANDARDS/ CODES

- a) The following Standard Specifications and Codes of Practice, currently applicable and updated as of date irrespective of dates given below, shall apply to the Elevators and the work covered by this contract.

National Building Code of India	NBC - 2016
Code of Practice for installation, operation and maintenance of electric passenger & goods lifts.	IS-14665 (Part 2) Sec-1 : 2000
Code of practice for installation, operation and maintenance of electric service lifts.	IS-14665 (Part 2) Sec-2 : 2000
MRL Code of Practice	IS-15785:-2007
Safety Rules Section-1 Passenger and Good lifts	IS-14665 (Part 3) Sec-1 : 2000
Safety Rules Section-2 ' Service lifts	IS-14665 (Part 3) Sec-2 : 2000
Outline dimension for electric lifts.	IS-14665 (Part-1) : 2000
Inspection Manual for Electric lifts	IS-14665 (Part 5) : 1999
Electric Traction lifts ' Components	IS-14665 (Part 4) Sec-1 to 9 : 2001
Installation And Maintenance of lifts For Handicapped Persons (Code of Practice)	IS 15330 :2003
Specification for lifts cables.	IS-4289 (Par-1) : 1984 Reaffirmed 1991
Specification for hot rolled and slit steel tee bars.	IS-1173-1978 Reaffirmed 1987

Method of loading rating of worm gear.	IS-7443-1974 Reaffirmed 1991
Code of practice for selection of standard worm and helical gearbox.	IS-7403-1974 Reaffirmed 1991
Isometrics screw threads.	IS-4218-(Part-II) 1976 Reaffirmed 1996
Degree of protection provided by enclosure for low voltage switchgear and control gear.	IS-2147-1962
Classification of insulating materials for electrical machinery and apparatus in relation to their thermal stability in service.	IS-1271-1985 Reaffirmed 1990
Code of practice for earthing.	IS-3043-1987
Electrical installation Fire Safety of Building.	IS-1646-1997
PVC insulated electric cable for working voltage up to and including 1100 volts.	IS-694-1990
Code of practice for electrical wiring and installation	IS-732-1989
PVC insulated (Heavy Duty) electric cables for working voltage up to and including 1100 volts.	IS-1554-1988 (Part-1)
Flexible steel conduits	IS-3480-1966
Accessories for rigid steel conduit for electrical wiring	IS-3837-1976
Boxes for the enclosure of electrical accessories	IS-5133-1969 (Part 1)
Guide for safety procedures and practices in electrical work	IS-5216-1982 (Part-1)
Conductors for insulated electric cables and flexible cords	IS-8130-1984
Miniature Circuit Breakers	IS-8828-1996
Rigid steel conduits for electrical wiring (Second revisions)	IS-9537-1981
Methods of test for cables	IS-10810-1998
Earth Leakage Circuit Breakers.	IS-12640-1988
Molded Case Circuit Breakers	IS-13947-1993
General requirement for switchgear and control gear for voltage not exceeding 1000 volts.	IS-13947-1993
1100 volt grade XLPE insulated armoured cables	IS 7098
Specifications for hoist way door-locks	IS 7754-1975
Rules for design, installation, testing and operation of lifts, escalators and moving parts.	IS 1735-1975

Seismic Zone: Comply with code requirements for seismic risk zone-III	IS: 1893-Part 1 & 2 -2002
Safety rules for the construction and installation of lifts - Lifts for the transport of persons and goods - Passenger and goods passenger lifts	EN 81-20
Safety rules for the construction and installation of lifts. Examinations and tests. Design rules, calculations, examinations and tests of lifts components	EN 81-50
Remote alarm on passenger and goods lifts	EN 81-28
Accessibility to lifts for persons including persons with disabilities	EN 81-70
Fire fighters lifts	EN 81-72
Behaviour of lifts in the event of fire	EN 81-73
Safety Code for lifts and Escalators	EN 81-80
Electromagnetic Compatibility	EN 12015 & EN 12016
Maintenance Instructions for lifts and Escalators	EN 13015
Life Safety Code	NFPA 101

- b) In addition, the relevant clauses of the following, as amended up to date shall also apply:
- The Indian Electricity Rules 1956
 - The Indian Electricity Act 1910
 - Local Fire safety regulations x Building Bye-Laws
 - CPWD specification for Lifts and Escalators work
 - Any applicable local lift/ elevators act/ rule for design and installation of the elevators
- c) In the event of a conflict between any of the above applicable or reference standards, the more stringent requirements shall take precedence.

1.1 TECHNICAL PARAMETERS

As per OEM recommendations.

1.2 Design

The design of the equipment shall match the design & performance requirements as specified below.

1.2.1 Proved Design

The elevators contractor shall develop the design based on the below specifications and on proven and reliable engineering practices. All sub systems & equipment shall be of proven design.

1.2.2 Design Criteria

The design of the equipment offered should meet the following criteria: -

- Usage of the latest state of the art technology.
- Design enhancements should not reduce the life cycle of equipment/ components
- Design life of at least 20 years
- Highest levels of reliability & equipment availability
- Lowest maintenance cost
- Modular design
- Minimum life cycle cost
- High traceability of components through unique bar coding/ serial nos./ tagging
- Lowest energy consumption
- Highest levels of safety
- Environment friendly
- Code compliance

1.2.3 Design Intent

The intent of this document is to make sure that the design of the elevators must follow the design criteria per above & to ensure the performance parameters to be met not only at the stage of handover but consistently year over year during the service life cycle. The elevators shall be provided with built in diagnostics to enable maintenance staff to reduce down times & to demonstrate performance requirements to AAI.

2.0 CAPACITY & SPEED

- a) The capacity of the elevators shall be 15/16 Passengers.
- b) Elevators Speed shall be 1.5 M/s.

3.0 SIZE

- a) The sizes shall have to be physically verified at site before manufacturing of the Elevators material.

4.0 DRIVING MECHANISM & ACCESSORIES:

4.1 Elevators Machine

The elevators machine shall be suitable for 415 volts, 3 phase, 50 Hz AC supply with a voltage variation of $\pm 10\%$ and frequency variation of $\pm 5\%$ and shall be placed inside the top of hoist way either on the steel beams or self-supported on the rails as per the manufacturer's design. The elevators machine shall have high efficiency equivalent to IE3 or above, high power factor and low power consumption and shall be designed to withstand peak currents in elevators duties. Resilient anti-vibration mountings of suitable design shall be provided to minimize vibration transmission to the building structure.

The assembly is to be designed & tested to sustain contract load plus 25% overload. The elevators shall have a gearless machine with permanent magnet consisting of motor traction sheave completely aligned on a single shaft. Gearless machine shall be AC PMSM (Permanent Magnet Synchronous Motor) gearless with VVVF drive. The sheave should have grooves/wedges for PVC coated traction belts/ ropes as specified in MRL code of Practice IS- 15785:2007. The machine shall be placed at the top inside of the hoist way on steel beams/ rails. Requirements for permanent lifting hooks, hoisting

beams and access hatches shall be indicated on the drawings by the elevators system, supplier/ installer.

4.2 AC Motor

The AC self-lubricating motor shall be suitable for elevators use with high starting torque and low starting current. Thermistors shall be embedded in the stator windings to indicate the temperature rise in the motor. The A C motor shall have Class F insulation and shall be designed for not less than 180 starts per hour with a maximum temperature rise of 50-degree C over the ambient when run continuously for an hour without any additional or assisted cooling.

The elevators shall be provided with AC variable voltage variable frequency (VVVF), microprocessor controlled motion and drive control system. The elevators system, supplier/ installer shall provide the model No., name of manufacturer and country of origin.

4.3 Anti-Vibration Supports

The whole traction machine shall be mounted on appropriate anti-vibration supports to minimize noise & vibration and to meet the ride quality parameters desired in this document.

4.4 Brake

- a. The electromagnetic brake or permanent magnet brake shall be spring applied and electrically released. It shall come into action after the elevators has come to a complete halt to hold the car in position. The brake shall operate automatically with the safety devices and failure of the mains. It shall be released electrically. It shall be possible to release the brake manually ' such release requiring the action of manual force to move the elevators in short stops for machine above equipment. In case of machine room less elevators, elevators contractor shall provide suitable means to hand wind or lower the elevators from a remote point.
- b. The brake shall be capable of stopping and holding the Elevators car in its downward travel to rest with 125% of its rated load from the maximum governor tripping speed. In this condition the retardation of the Car shall not exceed that resulting from the operation of the Safety gear or stopping on the buffer.
- c. Springs used to apply the brake shoes shall be in compression and adequately supported.
- d. Brake linings shall be of renewable incombustible materials and shall be secured to the brake shoes such that normal wear shall not weaken their fixings. Band brakes shall not be used.
- e. No earth fault, short circuit or residual magnetism shall prevent the brake from being applied in the event of loss of power supply to the Elevators motor and control circuit.
- f. A means of adjusting the brake plunger stroke and releasing the brake in emergency shall be provided.
- g. The Elevators machine shall be fitted with a manual emergency device capable of having the brake released by hand and requiring a constant effort to keep the brake open.

- h. The fail safe break shall incorporate an approved design of brake switch i.e. pick up, hold, discharge. Brake coil shall be wired in series & their respective switches in parallel. The operation of brake shall be thyristor controlled from solid state drive in order to affect minimum pick up time and synchronized start.
- i. The fail safe break shall be tested and adjusted at the manufacturers works to provide a braking torque of at least 1.5 times the motor torque output required to elevators full load + 10 % in the up direction. The resultant final length of brake springs shall be stamped on a suitable nameplate adjacent to the fail-safe brake. Solenoid air gap dimension, if used, will also be stamped on the nameplate.
- j. The Elevators machine shall be fitted with a manual electrical emergency device with battery backup capable of having the brake released by hand and requiring a constant effort to keep the brake open. In case of MRL elevators, the motor brake shall be able to be remotely released outside the elevators well.

4.5 *Suspension Ropes/ Belts*

Suspension Ropes/ Hoist Ropes shall be self-lubricated; round stranded steel wire ropes manufactured from high grade steel and special flexible material and shall conform to the IS- 2365 / EN81-20. The minimum tensile strength of the ropes shall not be less than 1230 N/ sq.mm. Suitable no. of hoist ropes and size of the hoist ropes shall be so selected that it has the combined breaking strength calculated with a minimum factor of safety of 12 times the combined weight of car with full load and also have adequate traction for the elevators. The governor ropes shall also be wire ropes.

Elevators using belts as suspension/ traction media shall conform to factor of safety mentioned above and shall be designed based on the relevant Indian/European Norms.

4.6 *Compensating Chains / Ropes*

Compensating chains or ropes shall be installed for the elevators if required to compensate the shifting mass of the suspension ropes. In case compensating ropes are used, a tension pulley with weight shall be provided with suitable guides mounted in the pit to ensure proper tensioning of the ropes.

These Chains or Ropes shall not be a cause for any noise and suitable flame resistant casing or jacket etc. shall be provided.

4.7 *Alignment*

- a) The brake plunger, collar, sleeve, motor, sheaves and all bearings shall be mounted and assembled so that proper alignment of these parts is maintained.
- b) The assembly shall be reviewed and rectified when excessive noise is emitted during operation.

4.8 *Car Safety, Counterweight safety and Governor:*

Car and Counterweight safety shall be provided to stop the car or counterweight whenever excessive descending speed is attained.

Mechanical safety gear shall be mounted on and securely fastened to car/ counterweight frame and actuated by a governor mounted in machine/ shaft. Governor shall be directly driven by steel wire ropes.

In machine room less applications, the governor shall be mounted in the overhead area of the hoist way. The manual tripping and resetting of the over speed governor shall be remotely controlled from outside the elevators well at the top-serving floor.

Safety gear shall hold car securely under maximum load and governor tripping speed conditions. Jaws of gear shall engage guide rails through self-aligning shoes with surfaces carefully machined parallel to guide rail face. Pressure of jaws on the two guides shall be equal. Safety gear shall bring car to stop from governor tripping speed. Method of stopping shall be progressive as specified in Elevators Schedule. Deceleration shall be less than gravity. Governor shall be accurately adjusted and sealed to electrically trip safety gear at a speed at least equal to 115% of car's specified speed. The maximum allowable tripping speed shall be as specified in EN 81-20 / IS-14665. Operation of governor on over speed is also to open a switch disconnecting power from motor and break control circuits, which are to be open before safety gear is applied. Restoration of power shall not be possible until safety gear has been manually re-set. Electrical tripping & Mechanical tripping will appear at about 1.1 to 1.25 times the rated speed. Double trip (downward and upward) protection shall be in accordance with EN 81-20 / IS-14665. The elevators system supplier/ installer shall submit required related type tests certificates to the Contractor.

A similar safety needs to be provided for counterweight as well in case of elevators with hanging pit/s and as a means for ascending car over speed protection. The governor tension weight shall be provided with a built-in switch to detect broken rope/belt.

4.9 *Driving Sheaves*

- a) The sheaves shall be manufactured in steel or SG iron and fitted with sealed for life lubricated bearings.
- b) The sheaves shall have machined rope grooves that can be reworked for future wear.
- c) Adequate provision shall be made to prevent any suspension ropes leaving groove due to rope slack or introduction of foreign objects.
- d) All traction & diverter sheaves shall be enclosed with a suitable & removable guarding for eliminating moving equipment pinching hazards.

5.0 CONTROL SYSTEM

5.1 *Controller*

The elevators shall have state of art microprocessor based AC variable voltage variable frequency (ACVVVF) drive.

The elevators controller shall be wall/guidrail mounted, vertical, totally enclosed cubicle type with hinged doors on the front and/or the rear to provide easy access to all components in the controller. The cubicle shall be well ventilated such that the temperature inside never exceeds the safe limits of the components at ambient room conditions in the hoist way.

The controller shall operate within the supply voltage variation of $\pm 10\%$ and frequency variation of $\pm 5\%$ of the nominal voltage. An inbuilt voltage stabilizer shall be provided in the controller for the purpose.

The controller shall be complete with relay protection against the following:

- Over current

- Under voltage
- Single phasing
- Phase reversal
- Earth leakage
- Over voltage
- Under voltage
- Spikes & Surges
- Heat Sink Over temperature
- Stall prevention (During acceleration, deceleration and constant speed operation)
Control panels & drive systems shall be designed to meet the requirements laid down by the EN12015 standards relevant to Electro-Magnetic Compatibility (EMC).

Elevators motor control system shall be electronic closed-loop control to ensure fail safe motor over speed controls and stopping accuracy of ± 3 mm.

Load compensation circuits shall also be included to further improve upon the levelling accuracy. The levelling shall be ensured within ± 5 mm.

An Automatic Phase reversal device shall be provided on the controller which shall be designed to protect the elevators equipment against phase reversal and phase failure.

The controller shall be designed to cut off the power supply, apply the brake and bring the car to a rest in the event of any of the above failures occurring.

System should automatically restart when power is restored.

System memory should be retained in the event of power failure or disturbance.

Elevators should not go in to correction mode or correction run to the lowest floor / highest floor to update its position & memory.

The acceleration and deceleration shall be adjustable at site using a service tool.

5.2 VVVF Drive Unit

Elevators drive controls shall be A.C. Variable Voltage Variable Frequency (ACVVVF) Drive System with microprocessor based site programmable controls.

In normal operation, the electromagnetic brake shall only be applied when the elevators have come to a complete standstill. The brake shall hold the elevators in position at every landing, and shall provide stopping without any jerking effect.

The VVVF Drive shall employ Sine wave PWM control & shall be designed to run at an ambient temperature of 50 °C and maximum relative humidity of 90%.

The VVVF drive shall be vector with flow closed loop control always.

Shielded cables to be used to cover the path from inverter output terminal box to motor terminal box; this is required to reduce EMI or radio disturbances.

Input filters to be used at inverter input to reduce disturbance to power supply. To safe guard motor against these voltage spikes, VVVF drive shall consist of appropriate protection device at output of the inverter. Following protections shall be built in with the inverter: -

- Motor overload/ over torque
- Instantaneous over current
- Ground fault
- Under voltage
- Over voltage
- Output & Input phase loss
- Output short circuit
- Over speed

- Spikes & Surges
- Heat Sink Over temperature
- Stall prevention (During acceleration, deceleration and constant speed operation)
On fault occurrence, the VVVF drive shall store the status of all parameters prevailing at the time of fault occurrence etc. & the same shall be available to the user to assist him in the fault diagnosis.

5.3 Up/Down Selective Collective Automatic Operation with or Without Attendant (Simplex Control System)

Individual elevators cars shall be provided with Simplex Control. The Elevators shall respond to all registered hall calls and car calls automatically with the help of one button per Elevators stop inside car and UP & DOWN buttons in each landing except the terminal landings where only UP or DOWN buttons are provided. It shall respond to all registered hall calls and car calls in the direction of service. When no call is registered then after a pre-set adjustable period Elevators car shall come to designated floor and open the door for 30 seconds (adjustable time) and then park the car there with doors closed.

Apart from above, a two position key-operated switch marked to indicate “**ATT**” (Attendant Operation) and “**AUTO**” (Automatic Mode) shall be provided. When the switch is in the position of “**ATT**” mode, the Elevators shall be in attendant mode.

It will connect the hall button pushes to the annunciator provided in the car, to register the calls.

5.4 Energy Efficiency

The control systems should incorporate energy control features to reduce the power consumption when the elevators are not in use or there is low demand; these include but not limited to: -

- Auto Fan/ Car light Cut-off: Auto switch off feature to be provided for switching of the ventilation fan & car lights after 90 seconds of elevators being idle. This should be programmable at site to increase or decrease the timing. These have to switch ON automatically at the time of first landing call.
- In low demand times (Off Peak Hours), number of service cars to be reduced without impacting passenger waiting times.

5.5 Fire Man Operation

All the elevators in the building shall be equipped with a control system to recall and operate cars in the event of fire or any other emergency situations. This shall always be in line with the latest IS codes/ EN codes/ NFPA standards amended up to date even if the below description is found as different from the latest amended codes mentioned here.

- a) Operation Requirement of elevators(s): -
All elevators(s) shall be provided with the following as a minimum: -

- A two position ON/OFF fireman's switch which may be common to all elevators in a group control at evacuation floor (normally the main entrance floor) protected in a box with glass in front with suitable label indicating that it is the fireman switch and
 - Audio & visual signal in car for Fire or any other emergency
- b) Sequence of operation: -
- Return to Evacuation floor (Phase1): -
- Shall start when the switch at the evacuation floor is turned to the 'ON' position or the signal indicating a fire received from the automatic fire detection and alarm system (if provided by the BMS) is on. The elevators(s) controlled by this switch shall cancel car calls and separate from landing calls and no landing or car calls shall be registered. The audio and visual signal in car shall be turned on. All heat and smoke sensitive door reopening devices shall be rendered inoperative.
 - If the elevators are travelling towards evacuation floor, it shall continue driving to that floor.
 - If the elevators are travelling away from the evacuation floor, it shall reverse its direction at the nearest possible floor without opening its door and return non-stop to the evacuation floor.
 - If the elevators are standing at a floor other than the evacuation floor, it shall close the doors & start travelling non-stop to the evacuation floor.
 - When at the evacuation floor, the elevators will park with doors open.
 - The audio signal is turned off after this drive.
- Fireman's Service (Phase2):-
- The Phase 2 is started after Phase 1 if the fireman's switch is on.
 - The elevators do not respond to landing calls. All heat and smoke sensitive door reopening devices shall be rendered inoperative.
 - When the car call button is pressed the doors start closing. If the button is released before the doors are fully closed, they reopen. The car call is registered only after the doors are fully closed.
 - After registering a car call the elevators start driving to a call. If more than one car calls are registered, only the nearest call is answered & the remaining car calls will be cancelled at the first stop.
 - At the floors the doors are opened by pushing the door open button. If the button is released before the doors are fully open, they reclose.
 - The elevators return to normal service when it stands at the evacuation floor with door open & the fireman's switch is off or by an electric signal from the automatic fire detection system when it is reset.
- c) The breakdown or shut down of an elevator in a group of interconnected elevators shall not affect the return of the other elevators to the evacuation landing.
- d) The elevators will automatically be reset to normal operation by:
- An electrical signal from the automatic fire detection system when it is reset; or
 - The reset of the manual grounding switch.
- e) The fireman's switch shall be located adjacent to the elevators opening at the evacuation floor and shall be at a height of approximately 1.8 m above the floor level.
- f) Electrical components/switchgears within the elevators hoist way and on the car, located within 1.0 m of any wall containing landing doors shall be protected from dripping and splashing water and shall have ingress protection class not less than IPX3

5.6 Automatic Rescue Device

The ARD shall have the following specifications:

- ARD should move the elevators to the nearest landing in case of power failure during normal operation of elevators.
- ARD should monitor the normal power supply in the main controller and shall activate rescue operation within 10 seconds of normal power supply failure. It should bring the elevators to the nearest floor at a slower speed than the normal run. While proceeding to the nearest floor the elevators will detect the zone and stop. After the elevators has stopped, it automatically opens the doors and parks with door open. After the operation is completed by the ARD the elevators are automatically switched over to normal operation as soon as normal power supply resumes.
- In case the normal supply resumes during ARD in operation the elevators will continue to run in ARD mode until it reaches the nearest landing and the doors are fully opened. If normal power supply resumes when the elevators are at the landing, it will automatically be switched to normal power operation and start from there instead of getting into correction mode and going to lowest floor.
- All the elevators safeties shall remain active during the ARD mode of operation x Audio/ Visual alarm to be provided in car to announce ARD operation; voice synthesizer to make an announcement that elevators is running to floor level on emergency power and to exit upon arrival.
- The battery capacity should be adequate so as to operate the ARD at least six times without recharging of battery.
- The ARD battery shall be dry and sealed maintenance free rechargeable type.

5.7 Seismic Operation and Safety Devices

Seismic operation Control system with primary wave sensors for all the elevators needs to be provided. It could be one control device installed in each isolated zone of the buildings (separated by expansion joints) which shall be integrated with all elevators units in that particular zone.

Upon detecting such wave& sensing the limit exceeding the programmed limit, the equipment shall direct the control system to bring the cars to the nearest floor and immediately open doors for safe exit. The electronic sensor should sense & measure acceleration across all three axis.

The elevators shall only be reset manually after the signal is clear and the maintenance personnel have inspected the elevators.

Upon Detection of a Seismic wave the control system shall provide for a signal to be sent to the BMS system.

Adequate protection such as protection wires, etc. as suggested in NBC-2016 shall be provided for Suspension ropes, governor ropes, travelling cables, compensating chains and ropes from swaying in the elevators hoist way and getting entangled with the fixed brackets, sill, equipment, etc. inside the hoist way.

Car and Counterweight retaining devices as per NBC-2016 shall be provided for all the elevators to hold the Car and Counterweight frames within the guiderails during seismic movement.

A “**counterweight derailment**” device or “**displacement switch**” shall be installed on counterweight guide rails which are to be activated in case counterweight sections are dislodged from original position between the guiderails due to seismic movements.

An automatic reset shall not be possible in such case and the elevators shall remain inoperable until the counterweight sections and guiderails are inspected thoroughly and defects are rectified by the maintenance personnel.

6.0 STANDARD FEATURES TO BE INCLUDED

6.1 AUTOMATIC BY-PASS

Load weighing devices located either on car top or under the car cage shall be provided for all elevators. Whenever the load exceeds 80% of the capacity load of the elevators, the elevators shall ignore all landing calls and only respond to car calls. Landing calls which are bypassed shall not be canceled. The automatic load bypass device shall be field adjusted for 50%-80% of rated load.

6.2 Over Load Device

A load weighing devices shall operate when the load in the car exceeds the rated capacity. The operation of the device shall activate buzzer sound and flashing 'overload' signals. At the same time the car doors shall be prevented from closing. When the excess load has been removed from the car, the buzzer alarm shall stop automatically and the car shall function normally. The sensitivity shall be 30 kg for Passenger elevators and 5% of the contract load for service elevators. The load sensing shall be achieved either by way of load sensors placed under car platform or rope/ belt tension device as per manufacturers standard design. The load sensing device should be site-programmable/adjustment type.

6.3 Automatic Self-Leveling

All elevators shall be provided with automatic self-leveling feature that shall bring the elevators car level to within ± 3 mm for passenger/service elevators and ± 5 mm for freight elevators of the landing floor regardless of load or direction of travel. The automatic self-leveling feature shall take care for over/ under travel.

6.4 Alarm Bell/Buzzer

An Emergency alarm bell/ Buzzer, including wiring to be provided and connected to a properly marked push button in the car operating panel. The alarm bell shall be located at the Main Landing floor, at the floor landing outside and adjacent to hoist way or as desired by AAI.

The alarm sound shall be siren type audible from at least 50 meters from the Main landing, operated by Rechargeable Nickel/Cadmium maintenance free batteries to give a warning siren when the alarm button in the car is pressed momentarily.

6.5 Safe Landing Feature

If a car has stopped between floors due to some equipment malfunction, the controller checks the cause, and if it is considered safe to move the car, the car will move to the nearest floor at low speed and the doors will open.

6.6 Automatic Door Open Time Adjustment

The time the doors are open will automatically be adjusted depending upon whether the stop was called from a hall call or a car call.

6.7 Next Landing

If the elevators doors do not open fully at the destination floor, then the doors will close and the elevators will automatically move to its next destination.

6.8 Independent Service

Under this operation the car is withdrawn from the group control operation for independent use, such as transporting goods, carrying large number of people between floors or maintenance & at such times only responds to car calls. The elevators will remain parked on a floor with its doors open until a floor is selected and the door close button is held until the elevators starts to travel. The switch for this service shall be located inside the lockable service box in Car operating panel.

6.9 Return Operation

Using a key switch on the face plate at main lobby floor, an elevator can be taken out of the group control operation & brought to the main lobby floor (or other designated floor). The car will park on that floor with the doors open till independent operation begins.

6.10 Car Call Cancellation

This function allows passenger to cancel the selection of a floor which is accidentally pressed by pressing the button again.

7.0 CAR ENCLOSURE

7.1 Car Frame

The car frame/sling shall be fabricated from steel angle or channel section and be separate from the elevators car. The safety gear positioned below the sling shall be of gradually applied type, which can be released by lifting the car. This safety gear shall be operated by an over speed governor located in the top of hoist way. The governor tension weight shall be provided with a built-in switch to detect broken rope/belt. Sheet steel thickness for Car shall be at least 1.5 mm. Joints in all surfaces shall be coordinated. All fixings to be of the hidden secret type (cover strips at joints are not acceptable).

Platform shall be isolated type, constructed of steel, or steel and wood which is fireproofed on underside. Design and construct to accommodate load classification requirements. Protect underside of platform with sheet steel covering at least 2.0 mm thick. Sill shall be anti-slip, with provision for car doors. Sill shall be of the type reducing the number of call backs related to entrance problems.

Every elevators car body shall be carried in a steel car frame assembly that shall have sufficient mechanical strength to resist the forces applied by the safety gear or impact of the car on the buffers. The deflection of the steel members carrying the platform shall not exceed 1/1000 of their span under static conditions when the rated load is evenly distributed on the platform.

Every elevator shall be provided with an apron of at least 750 mm below car door. This apron should extend up to full width of the car door plus 150 mm on the either side. This apron must be rigidly braced with only countersunk screws & any fixings/ mountings used shall be of steel.

The car roof shall be provided with a car top rail/ balustrade in accordance with the requirements of EN 81-20 including a mid-rail& toe guard where applicable. A suitable warning notice for the fall hazard shall be placed.

At least four renewable guide shoes or shoes with renewable linings or sets of guide rollers shall be provided two at the top and two at the bottom of the car frame assembly.

7.2 Car Enclosure Finishes

Car enclosures shall be stainless steel (SS 304) hairline finish or Clear Tempered Glass Scenic Elevators or as per design and technical specifications.

All finishing materials shall be fireproof or fire resistant conforming to applicable codes.

7.3 Car Cabin Construction

Height of the enclosures shall be 2700 mm. The enclosure shall have recessed by 25mm to enable Civil Contractor to provide floor finish as approved by AAI. The weight to be allowed for flooring shall be as specified by OEM. Enclosure shall have Stainless Steel false ceiling with LED cluster lights or as approved by AAI. The enclosure shall have fixtures and fittings including provision of car ventilation.

The material chosen for car walls, floors and ceiling must meet fire resistance classification requirement in accordance to EN81-20 and as specified in EN 13501-1.

7.4 Cabin Fan

At least two numbers Noiseless pressure fan or blower shall be provided in each elevators cabin with supply grill matching with the interior of the car. The required no. of cabin fans shall be adequate for 20 air changes per hour with Car doors closed. Airflow in the car should be such that adequate amount of airflow reaches all parts of cabin. One of the blowers shall be connected through a rechargeable UPS to ensure continuous blower operation for at least 15 minutes in event of power failure.

7.5 Emergency Lights

In addition to normal lighting an emergency light unit using sealed Nickel/Cadmium Maintenance free battery power pack with charger and fluorescent lamp to operate automatically and to illuminate the car for minimum 30 minutes in case of power failure shall be provided in each elevators car.

An "Emergency light test" button to verify the proper functioning of car emergency lights shall be provided inside the service cabinet in the Car operating panel. When this button is pressed, the main car lighting should be disconnected and emergency car light should get illuminated thus verifying the proper functioning of emergency lights including rechargeable batteries.

7.6 Guide Shoes

Two number of guide shoes at the top and bottom shall be provided on the elevators car & counterweight. Guide shoes shall have non-metallic renewable lining's, which requires minimum lubrication.

Sliding guide shoes for car & counterweight shall always be of spring loaded adjustable type.

8.0 CAR SIGNALS & OPERATION DEVICES:

8.1 For Cars with Simplex/ Duplex Control

A flush type Stainless Steel "Car Operating Panel (COP)" with the following devices shall be fitted:

- Bank of call buttons corresponding to landings served. Tactile braille LED illuminated Buttons.
 - The push buttons should be tonal contrast to the COP & car panels finish
 - Each push of any COP button shall provide a soft audible signal to confirm operation.
 - Alarm button shall be provided with a yellow pictogram to indicate the alarm button provision.
 - Fan /Blower switch.
 - Door open button.
 - Door close button.
 - "Up" & "Down" direction indicators indicating travel direction Key operated switch for "Attendant" and "Automatic" operation.
 - Provision in car to be connected with P.A. System, Fire Control Room, CCTV and BMS Control Room.
 - Overload panel along with audio/visual indication.
 - In case of service elevators& bed cum passenger elevators, provide door hold button, which extends normal door open period by up to 30 seconds. The extended time can be cancelled by actuation of door close button.
 - Adequate space provision for access control card reader, if required.
- a) A load weighing device shall be provided to by-pass landing calls, should the load of the elevators reach 80% of the full contract load.
 - b) The Fan /Blower switch shall be a tactile push type switch located inside the service cabinet of Car operating panel. Fan / Blowers shall be isolated with vibration isolators from the car and the sling. The "up" and "down" reversal buttons and key operated inspection switch shall be provided on a maintenance control device on top of the elevators car.
 - c) In case of "Attendant" operation of the car indicator on the car station shall be provided for the attendant to know on which landing the call has been registered to answer that call.
 - d) If the sole control of the elevators is to be retained on the car station, a car preference switch shall be provided to ignore all landing calls.
 - e) A LCD / LED based/ scrolling digital car position indicator with LED/LCD illumination shall be provided in each elevators car indicating the landing at which the car is stopped or passing. Car enclosure will be provided with arrangement for fixing of Internal Telephone. Car shall have a provision for communication with main control room/ fire control room.

8.2 Emergency Intercom

Each elevator shall be fitted with an intercom system to allow atleast 3-way, hands free, conversation between the elevators car, Maintenance access panel and two remote stations. The microphone & speaker unit has to be concealed behind the COP in the elevators car & is activated by pressing the button which has an indication glowing when intercom is in operation.

The master unit in the remote stations has to have an indicator for each elevator.

8.3 Voice Synthesizer

This shall be provided & needs to be of the digital type capable of site programming. Besides giving a choice of background music (with option at site to choose or reject) it should be capable of providing following messages in at least two languages per choice of the owner:

- Arrival at the floor & its designation.
- Door closing initiated.
- Elevators failed to start, please press the door open button
- ARD operation

Final messages list & wording to specified/ approved by AAI.

9.0 CAR & LANDING DOORS

9.1 Door Operator& Locks

Door operator shall be positive acting and powered by an A.C motor rigidly connected to the door and controlled by a VVVF unit. Operator shall simultaneously open the car and hoist way doors and maintain the doors fully open or closed at each door step. Door operators shall be suitable for Attendant/Automatic operation. The door operation shall ensure smooth opening of door without any jerk and closing of door without any banging noise.

The operator and closed loop VVVF control panel and its associated devices should be mounted on steel members forming part of the car sling & in no way shall the operator be fitted to the car enclosure.

Direct door drives through PMSM motors driven through closed loop VVVF drive shall be the preferred method.

The equipment shall consist of a door operator unit on the elevators car operating the car door when the car is stopping at a landing. The car door and hoist way door shall be mechanically coupled and shall move simultaneously during opening and closing.

The car door and the hoist way door shall be power opened and power closed and shall be checked in opening and closing with an oil cushioning mechanism built into the gear unit if any; nylon/ plastic gears will not be acceptable.

Each hoist way door shall be provided with an interlock, which will prevent movement of the car away from the landing until the doors are locked in the closed position.

An electric contact for the door shall be provided which shall prevent car movement away from the landing unless the door is in fully closed position.

The car door and the hoist way shall open automatically as the car is stopping at a landing. The closing of the car door must occur before the car can be started. Doors can be stopped and reversed during their closing motion.

9.2 Door Hangers and Tracks:

The car and the landing doors shall be provided with two-point suspension sheave type hangers complete with tracks. Sheaves and rollers shall be steel with moulded nylon collar and shall include shielded ball bearings. Tracks shall be of suitable steel section with smooth surface. The landing doors shall be complete with headers, sills, frames etc. as required.

9.3 Car & Hoist way Door Protection:

A multiple beam full height infrared electronic door detector shall be provided to regulate the closing motion of the doors for entry of the passengers. When a person is entering the car while the doors are closing the detector shall sense the same and reverses the door closing to permit entry. The operation of detector shall be of non-contact type.

9.4 Car & Landing Doors:

The car & landing entrances for elevators shall be protected by automatic power operated, center opening/2 Speed side opening, horizontal sliding doors with size and finish as per OEM.

Car entrance shall be protected by steel doors of the same size as landing doors.

Elevators shall be provided with automatic doors

The door shall be provided with Multi beam Infra-red sensors, high speed door operators, sheave type two point hangers, and tracks as specified.

The thickness of the door panels shall be at least 1.5 mm and shall be of single skin construction.

The face of the door panels shall maintain a fixed running clearance with respect to the architrave and/ or door frame.

Every landing door shall be provided with an emergency landing door unlocking device. When operated by an authorized person with the aid of a key to fit the unlocking triangle, the landing door shall be unlocked irrespective of the position of the elevators car for rescue purpose. When there is no "unlocking" action, the key shall only be able to stay in the locked position.

In the case of coupled car and landing doors, the landing doors shall be automatically closed by means of weight or springs when the car is outside the unlocking zone.

A potential cause of accidents could be the attempt to open the landing door locks of lower floor in case car stops away from floor level. This attempt in panic may result in an accidental fall in to the elevators pit. In order to ensure that the trapped passengers do not attempt the above, the electromechanical latch should be so designed that it is inaccessible or invisible to the passenger in car. In addition to above, a car door lock mechanism shall be provided in accordance to EN81-20 to prevent opening of the car door from inside the elevators car when it is not in close proximity to the landing doors. Each landing door shall be complete with locks, headers, sills, frames, rims, hanger supports with cover plates, etc. The finished work shall be strong, rigid & neat in appearance. Plain surface will be smooth & free from warp or buckle. Molded surfaces shall clean out, straight & true. Fastenings shall be concealed from the fascia side of the material.

For all elevators in buildings the landing doors will need to have a minimum fire resistance rating of 01(One) hours for integrity. Necessary certification from a nationally recognized testing laboratory approved within the governing jurisdiction shall be submitted to the Contractor before shipment.

10.0 LANDING SIGNALS AND OPERATION CONTROLS

10.1 Simplex / Duplex Control

Terminal Landings

- LED illuminated type single push buttons with travel indication arrow in hairline finish stainless steel fascia plate.
- Color LCD/ LED Dot Matrix type Digital car position indicator in hairline stainless steel fascia plate or as specified in the Annexure 1 or as approved by AAI.
- Direction & position indicators requirement is mutually exclusive and both displays have to work simultaneously.

Intermediate Landings

- Two LED illuminated type push buttons with travel indication arrow in hairline finish stainless steel fascia plate.
- Color LCD/ LED Dot Matrix type Digital car position indicator in hairline stainless steel fascia as approved by AAI.
- Direction & position indicators requirement is mutually exclusive and both displays have to work simultaneously.

The number of risers shall be as specified/ approved by AAI.

Surface mounted face plates will be preferred though the final approval on faceplate design shall be provided by AAI. The cover plates should be secured by semisecret fixings such as recessed captive grub or socket headed screws but not by visible screw heads. Options of faceplates/ buttons/ indicators/ hall lanterns to be submitted by elevators system supplier/ installer for approval by AAI.

The indicators should provide an angle of view of 140 degrees.

10.2 Elevators Identification Plates:

Elevators identification numbers stating e.g. "ELEVATORS 5 shall be provided in the following locations for each elevators by the elevators contractor: -

- All landing entrance headers
- Top of the COP in car
- On each elevators control panel
- Each Car top control station
- Each Machine
- Each safety governor
- Each pit switch

These may be painted except for the ones required for first two items above, which will need to be engraved on matching material to each item as approved by the architect.

11.0 ELEVATORS SHAFT & PIT**11.1 Landing Fascia**

Fascia panels of minimum 1.6mm zinc coated mild sheet steel shall be fitted between the header of each entrance & the sill of the floor above.

These fascia plates must be rigidly braced & any fixings/ mountings used shall be of steel. Each fascia should be full width of entrance plus 150mm at least on either side and only counter sunk screws will be accepted on the surface.

Fascia panels post fitting have to be site painted to match all other site steel work.

11.2 Guide Rails

The Car and Counterweight guide rails shall be solid 'T' section, duly machined, tongued and grooved. The guide rails shall have sections, the properties of which shall comply with the requirement of the relevant IS/ EN codes. The guides shall be capable of withstanding forces resulting from the application of the car or counter weight safety devices.

The guide rails should be continuous throughout the entire travel and shall withstand without any deformation the action of safety gear with a fully loaded car.

Guide Rail brackets shall be fixed to the wall by anchor fasteners. Adequate steel brackets of suitable design and spacing shall be provided, so that guides shall not deflect more than 5 mm. under normal operation.

When rail lengths exceed 30m, means shall be provided to absorb rail expansion and structural settlement.

11.3 Buffers

Suitable heavy duty spring or oil buffers (depending on speed of the elevators) shall be placed below the car and counterweight in the pit and arranged to sustain any shock, should the elevators over travel past the terminal limits. Buffers shall be mounted on RCC foundation blocks. Dowels for the purpose shall be left while casting the pit floor. Clearance from underside of the car resting on a fully compressed buffer shall not be less than 1.20 mtr. Buffers shall be designed for a design speed + 15%.

The normal operation of the elevators shall depend on the return of the buffers to their normal extended position after operation. The device for checking this shall be an electric safety device mounted on the buffers.

11.4 Sills

The sills to be provided should be Stainless Steel grooved / Slot less, with self-supporting sill M.S. angle of adequate size.

11.5 Counter Weight

The counter weight shall be made of cast iron firmly fixed using 2 numbers tie rods and consist of structural steel frame which shall travel between rigid guides and also shall be capable of withstanding buffer impacts. The counter weight shall have weight equal to that of the complete elevators car and approximately 45-50% of the contract load. Suitable metallic counter weight guard of not less than 1.80 m shall be provided in the pit to avoid accidental contact.

11.6 Hitch Plates

The end of the elevators ropes shall be properly secured to the car and counter weight hitch plates as the case may be with adjustable rope shackles having individual tapers babbitt sockets, or any other suitable arrangement. Each elevators rope shackle shall be fitted with a suitable shackle spring, seat washer, shackle nut & lock & shackle nut split pin.

11.7 *Painting*

All elevators metal work shall be given one shop coat of rust inhibiting paint in the factory and painted with finishing coats on site. Factory finished powder coated paint of desired shade is acceptable. Any damage caused during erection of the equipment shall be repaired to restore it to required finish.

12.0 *SAFETY DEVICES*

All safety devices statutorily required by IS/ EN/ NBC standards, including but not restricted to the following shall be provided:

12.1 *Terminal and Final Limits*

Terminal limit switches shall be provided to slow down and stop the car automatically at the terminal landings, and final limit switches shall be furnished to automatically cut off power should the car travel beyond the terminal landings.

12.2 *Interlocking*

Each Hoist way gate/ Landing doors shall be provided with an approved interlock and which shall prevent the movement of the car away from the landing unless all gates are closed and locked. The interlock shall also prevent opening of gate except at the landing where the car is stopping or has stopped. Adequate interlocking is to be provided so that the car shall not move if the landing doors are even partially open and also the elevators is overloaded.

A car door lock mechanism shall also be provided in accordance to EN81-20 to prevent opening of the car door from inside the elevators car when it is not in close proximity to the landing doors.

12.3 *Self Leveling*

The elevators shall be provided with self-leveling features of ± 3 mm for passenger/ service elevators and ± 5 mm for freight elevators.

12.4 *Ascending Car Over Speed Protection*

The elevators shall be provided with an ascending car over speed protection device conforming to EN 81-20. This device shall comprise a speed monitoring and reducing element which shall detect uncontrolled movement of the ascending car at a minimum of 115% of the rated speed and a maximum of 125% of the rated speed. This shall cause the car to stop, or at least reduce its speed to that for which the counterweight buffer is designed.

The device shall not allow a retardation of the empty car in excess of 1g during the stopping phase. The device shall act to the car or the counterweight or on the rope system or on the traction sheave.

The device shall operate an electrical safety switch to switch off the power supply to the elevators motor. This safety switch shall not be of auto resetting type.

12.5 *Unintended Car Movement Protection*

The elevators shall be provided with a device to stop the unintended car movement away from the landing with the landing door not in the locked position and the car door

not in the closed position, as a result of failure in any single component of the elevators machine or drive control system upon which the safe movement of the car depends. The design and operation of such device shall conform to EN 81-20.

12.6 Pit Ladder & Switch

The elevators contractor shall provide fixed pit ladders between the bottom landing and the pit floor. These will be safe from all falling hazards.

Two pit stop switches, one at bottom landing level in the shaft & the other on the pit shall be provided, which, when in the STOP position, shall prevent any movement of the elevators car including movement during inspection operation, until both the switches are set in the run POSITION. The switch shall have a mushroom red head. It shall be locked off when pushed and reset manually.

First stop switch shall be accessible from the lower landing on opening of the landing door and the second switch from the pit floor.

Any switchgear or electrical equipment placed less than 1 m from the elevators pit floor shall be protected to IP 67 and any switch socket & lamp / light shall start from at least 0.5 m above the highest permissible water level in pit.

A permanent inspection control device in accordance to EN 81-20 shall be provided in the pit and accessible from the safety refuge space required in pit as per EN 81-20.

12.7 Safety Items

Following safety items shall be provided in for each elevators; Contractor to cover the cost of these items in his quoted rates, nothing extra shall be paid on this account.

- First Aid Box
- Co2 / foam based fire hydrant cylinders
- Danger Plates
- Electric shock treatment charts
- Any other safety item that may be required by authorities.

13.0 ELECTRICAL EQUIPMENT AND WIRING

13.1 Scope

The scope of this section comprises supply, installation and wiring of all electrical equipment including control wiring. Power supply at 415 V, 3-phase, 50 Hz, 4 wire with double earthing shall be supplied by designated system Contractor and terminating in MCB (TPN) in sheet steel enclosure for each elevator. All further wiring to motors and controllers, hall buttons, alarm bell, car position indicators etc. shall be provided by the elevators system supplier/ installer. All electrical installation shall be carried out as per standard practices of IS.

13.2 Wiring

All wires and cables shall be insulated with polyvinyl chloride base insulation rendered flame retardant low smoke halogen free (FRLSHF) armored and rated for 1100-volt service and suitable for use in dry and wet locations. Makes of wires and cables shall be as per attached list of approved makes in tender document and subject to the approval of AAI before delivery. Colour coding, numbering and ferruling to be in accordance with the requirements of standard specification.

All control wiring shall be of copper. All electrical wires and cables shall be fire retardant

low smoke emission and halogen free type (FRLSHF).

The control wiring shall be laid out neatly and clearly in cable sleeves and all terminals and cables shall be labeled or marked for identification.

Wires and cables subject to movement and abrasion shall be protected by flexible galvanized steel conduit.

A travelling cable for lighting control and signal circuit is permitted, if all the conductors of these travelling cables are insulated for maximum voltage running through any one conductor of this cable.

The lengths of the travelling cable shall be adequate to prevent any strain due to movement of car. All cables shall be properly tagged by metallic/ plastic tags for identification.

Travelling cables shall be of flat type and shall run from a junction box on the top of the car to a junction box located in the shaft bear mid-point of travel and from these junction boxes conductors shall be run to the various locations.

Travelling Cables shall have fire retardant low smoke halogen free type (FRLSHF) and moisture resistant outer covering with a steel-supporting strand. Travelling cables shall be suitably suspended to relieve strains in individual conductors.

Travelling cables shall be provided for telephone, signals, controls, lights, fans, alarm bell, emergency circuit, music and communication with control room etc.

Provide 10% of the total capacity subject to a minimum of 5 wire pairs unutilized in the Travelling cable everywhere suitably distributed between various functions.

Metal frames and all metal work of the elevators controller frame etc. shall be earthed with double earth leads taken to the earth bar. Looping shall be permitted if such routing is feasible. All other individual metallic framework of components etc. shall be loop earthed. All the elevators shall be provided with earthing arrangements as per IS 1860.

14.0 BMS COMPATIBILITY

- a) All the elevators shall be provided with necessary interfacing circuits for the BMS system in each Elevators controller, in order to achieve an integrated 'view' of the Elevators being monitored.
- b) Ethernet Interfaces shall be provided for any Elevators signal outputs, in order to directly interface with the BMS system. Similarly, necessary Ethernet Interfaces points shall be provided for any BMS signal inputs to the elevators controllers. These signals shall be collectively referred to as the interfacing I/O points.
- c) All field controllers shall connect to the Airport's Local Area Network via an RJ45 port which will be supplied by designated system contractor at a location to be defined by elevators system supplier/ installer.
- d) The designated system contractor for IT cabling shall supply a Cat 6 UTP patch cord.
- e) Controller network communications shall comply with the TCP/IP standard IEEE 802.3i
- f) Control and monitoring data which passes between the BMS and the elevators controller shall use a protocol which complies with one of the four standards listed below:
 - BACNet (BTL) certified
 - OPC Data Access Version 2.0
 - OPC Alarm & Events Version 1.02
 - OPC Historical Data Access
 - OPC XML-DA

- MODBUS
- g) These I/O points shall include, but not limited to, the following:
- Run/ Stop Status
 - Fire emergency mode
 - Digital car position and direction indicator
 - Attendant/ Independent Operation Status
 - Emergency Stop Operation Status
 - Safety switch tripped
 - Under Maintenance Mode Status
- h) I/O points interface shall be provided near the Elevators controller for BMS. An Ethernet /IP network interface & gateways needed to interface between Elevators controller equipment & Airport's backbone network shall be provided in order to integrate the respective elevators controllers.
- i) The Controller shall send the necessary information via the Ethernet /IP.

15.0 INTERFACE MANAGEMENT

The elevators system supplier/ installer shall initiate and manage the design, development, installation and testing of the interface between the elevators and the BMS system; the CCTV system; the Access Control systems; the Fire alarm systems; the Public Address systems and the wireless communication system.

16.0 RIDE QUALITY

16.1 Background

According to ISO 18738:2003 the elevators ride quality is defined as the noise level in the car and vibration on the car floor, which is relevant to the user perception and associated with elevators motion.

The following set of parameters is integral to the evaluation of the ride quality:

- Airborne noise level inside the car
- Horizontal car vibration
- Vertical car vibration
- Car acceleration
- Jerk

16.2 Applicable Standards

Airborne noise:

- L (Aeq) - A-weighted equivalent sound pressure level: can be interpreted as a mean level and measured directly with an integrating sound level meter.
- L (p) - Maximum A-weighted sound pressure level measured over the same time as the equivalent level.
- All sound pressure level measurements requiring setting "FAST" of the sound level meter.

Vibrations:

- a (xmaxPtP), a (ymaxPtP), a (zmaxPtP): ISO-weighted maximum peak to peak vibration value, according to ISO 18738:2003
- a (xA95), a (yA95), a (zA95): ISO-weighted A95 vibration value according to ISO

18738:2003. 95% of all peaks of the ISO-weighted signal are below this value. VDI 2566 Part 1: 2001: acoustical design for elevators with machine room ISO 18738:2003: elevators ' measurements of elevators ride quality

16.3 Ride Quality Performance Values

It is expected from the elevators contractor that his design of equipment will consequently lead to not only a very reliable, energy efficient, state of the art technology, high traffic handling efficient system but should also be able to achieve ride quality performance values as provided in the details below.

Elevators system supplier / installer shall arrange for the tools at the time of handover to show the results which are equal to or better than the value specified below.

Top Most Landing	
Airborne Noise	Max 58 dB(A)
Car (ISO 18738:2003)	
Airborne noise	
L(Aeq)	Max 48 dB(A)
L(P)	Max 57 dB(A)
Horizontal vibrations	
a(xmaxPtP) & a(ymaxPtP)	Max 20 mg
a(xA95) & a(yA95)	Max 15 mg
Vertical vibrations	
a(zmaxPtP)	Max 20 mg
a(zA95)	Max 15 mg
Airborne noise at landing floor	
Door movement noise L (p_door)	Max 52 dB(A)
Pass by noise L (p_landing)	Max 48 dB(A)

16.4 Other Performance parameters

Some of the other performance parameters required are innumerate below: -

- Starting Current - 1.2 ' 1.5-time full load running current
 - Leveling accuracy and - ± 3 mm for Passenger/service elevators
 ± 5 mm for freight elevators
- 1 Stopping accuracy - ± 3 mm
 - 2 Acceptable Voltage Fluctuation - + 10 to - 10%
 - 3 Acceptable Frequency Fluctuation - +5 to -5%
 - 4 Rate of acceleration/deceleration (M/S²)- 0.6 -1.5 (Adjustable at site)
 - 5 Maximum jerk (M/S³) - 0.7 -1.5 (Adjustable at site)

16.5 Measurement of Elevators Ride Quality

The Elevators system supplier/ installer shall at no additional cost measure elevators car

ride quality during the handing over of elevators for public usage and then annually for all elevators indicated, with specified ride quality parameters and forward printed results to AAI.

The ride quality measurement shall be taken with a recently calibrated Performance measuring tool, capable of displaying the test measurements on site, supplied by the Elevators system supplier/ installer.

17.0 PROVISIONS FOR SPECIALLY-ABLED PASSENGERS

All the Elevators shall have accessible friendly features including but not limited to the following:

- Elevators control buttons in the COP at locations and height specified in IS 15330 - 2003/ EN 81-70
- Hall call buttons at locations and height specified in IS 15330 - 2003/ EN 81-70
- Hand rails shall be provided on the side walls of the Elevators at height & locations specified in IS: 15330 - 2003 / EN 81-70.
- An international symbol of access of the disabled shall be permanently and conspicuously displayed at each and every Elevators landing next to the Elevators entrance (to be provided by signage contractor).
- Braille notations indicating the floor levels shall be incorporated next to each button at the COP and hall call buttons.
- A digital voice system for announcing the car position, opening/closing of doors, direction of travel and messages shall be provided as per IS:15330 - 2003/ EN 81-70
A laminated safety glass type mirror of at least half of the size shall be installed on rear panel at appropriate position as per IS: 15330 - 2003/ EN 81-70
- In the event of a conflict between any of the above applicable or reference standards, the more stringent requirements shall take precedence.

18.0 TESTING

AAI reserve the right to inspect the elevators and its components during manufacturing, installation & post installation.

18.1 Tests During Manufacturing

Testing for the various items of equipment shall be performed by the elevators system supplier/ installer. Test certificates for various components including but not limited to the following shall be furnished as per IS-14665 / EN81-20:

- Hoist ropes
- Governor ropes
- Over speed governor
- Buffers
- Main motor & Door drive motor
- Safety gear
- Fire rating for doors
- Controller

(a) Factory Inspection

- (i) AAI's authorized representative shall have full powers to examine the material and workmanship at the contractor's work or at any other place where the material or equipment is manufactured. Acceptance of any material or equipment shall in no way absolve the contractor of his responsibility for meeting the required specifications.
- (ii) Routine tests for the various items of equipment shall be performed at the contractor's manufacturing works and test certificates shall be furnished. The contractor shall permit AAI's authorized representative to be present during any of or all the acceptance test in respect of the equipment/work.
- (iii) Contractor shall give sufficient time notice for AAI's authorized representative for inspection at the original equipment manufacturers factory in India or abroad. All the expenditures in connection with deputing of Officials would be borne by AAI. However, in case inspection results are not satisfactory or all materials are not offered for inspection by the contractor, the cost of second inspection incurred by AAI shall be recovered from the bill of the contractor.
- (iv) The Elevators to be supplied under this contract shall be offered separately for factory inspection.

18.2 Tests During Installation

Tests & inspections - in stage - may be always/ randomly conducted for at least each of the following critical phases of work. This list is not inclusive but indicative.

48 hours' notice is required prior to completing these phases to enable AAI to carry out any checks deemed necessary. The following are the minimum requirements: -

- Setting out the plum lines
- Erection and alignment of guide rails & rail brackets
- Erection & alignment of landing doors, sills, header, jambs etc.
- Positioning of hoist way equipment & controller etc.
- Erection / Fixing of landing fixtures

18.3 Post Installation Tests at Site

Post installation test at site shall be conducted by the elevators system supplier/installed in the presence of AAI as per IS 14665 PART 3 and PART 5 and the below is not an inclusive list. Also the elevators system supplier/installer shall have to perform tests to confirm the performance parameters in the presence of AAI post installation and commissioning.

The tools & tackles required for such tests will have to be brought in by the elevators system supplier/installer. All test instruments shall be calibrated not more than one year prior to their use. The contractor may be asked to submit calibration certificates or other documents for proof of compliance.

a) Leveling Test

Accuracy of the floor leveling shall be tested with the elevators empty, fully loaded. The elevators shall be run to each floor while travelling both in upward and downward directions and the actual distance of car floor above/ below landing floor shall be measured. In each case there shall not be any appreciable difference in these measurements for leveling at the floors when the car is empty and when it is fully

loaded. The tolerances for leveling shall be as ± 3 mm for passenger/service elevators and ± 5 mm for freight elevators.

b) Safety Gear Test

Safety gear controlled by a governor should be tested with contract load and a contract speed, governor being operated by hand. Two tests should be made, however, with wedge clamps or flexible clamp safeties, one with contract load in the car and the other with 68 kg

(equivalent to one person) in the car. The stopping distance obtained should be compared with specified figures and the guides, car platform, and safety gear should be carefully examined afterwards for signs of permanent distortion.

Counterweight safety gear should be tripped by the counterweight governor and the stopping distance noted. In this case, however the governor tripping speed should exceed that of the car safety governor but by no more than 10 %.

During the safety gear test, car speed (from the governor or the main sheave) should be determined at the instant of tripping speed with that stated in IS/ EN. The governor jaws and rope should be examined for any undue wear.

c) Contract Speed

This should be measured with contract load in the car, with half load & with no load and should not vary from the contract speed by more than 3%. The convenient method is by counting the number of revolutions, made by the sheave or drum in a known time. Chalk mark on the sheave or drum and a stop switch will facilitate timing but care must be exercised to ensure that no acceleration or retardation periods are included. If the roping is 2 to 1 the sheave speed is twice the car speed. Alternatively, the speed can be measured by a tachometer applied directly to shaft or a contact free tachometer immediately below the sheave.

d) Elevators Balance

After the above test, some of the weight shall be removed until the remaining weights represent the figures specified by the bidder. With this condition car at half way travel the effort required to move the elevators car in either direction with the help of winding wheel shall be as nearly as can be judge by the same.

e) Car and landing doors interlocks

The elevators shall not move with any door open. The car door relay contact and the retiring release cam must be tested. The working of the door operation and the safety edges and light equipment if any provided shall also be examined.

f) Controllers

The operation of the contactors and interlocks shall be examined and it shall be ascertained whether all requirements laid down in the specifications have been met.

g) Normal Terminal Stopping Switches

This shall be tested by letting the car run to each terminal landing in turn, first with no load and then with contract load and by taking measurements, top and bottom over travels can be ascertained.

h) Final Terminal Stopping Switches

The normal terminal stopping switches shall be disconnected for this test. It shall be ensured that these switches operate before the buffers are engaged.

i) Insulation Resistance

This shall be measured (after removing the electronic PCB's and their connection) between power and control lines and earth and shall not be less than 5 mega-ohms when measured with D.C. voltage of 500 volts. Test certificates thus conducted in the controlled factory environment shall be submitted.

j) Earthing

All conduits, switches, casing and similar metal work shall have earthing continuity.

k) Ropes

The size, number construction and fastenings of the ropes should be carefully examined and recorded.

l) Buffers

The car should be run on to its buffers at contract speed and with contract load in the car to test whether there is any permanent distortion of the car or buffers. The counterweight buffers should be tested similarly.

m) Integrated System Test

The elevators system supplier/installer shall co-ordinate and carry out interfacing and integrated testing together with other System-wide Contractors to ensure that the all integrated systems function as desired.

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FITNESS CERTIFICATE (FORMAT)

FITNESS CERTIFICATE FOR ELEVATORS

(To be submitted in the Letter Head of the Service Agency / Contractor)

Date: __/ __/

TO WHOMSOEVER IT MAY CONCERN

I/We_____hereby certify that Elevators No._____Installed at
(Location) have been satisfactorily serviced including replacement of necessary spares (if any); Cleaned
and put back to public use on Date. The subject elevators/escalator are safe for use till the next planned
preventive maintenance.

Name of the Engineer:

Designation:

Date:

Signature and Company Seal:

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SEWAGE TREATMENT PLANT

10.1 BASIS OF DESIGN

1. The capacity/ rating of pumps and equipment etc. shall hold good for the capacity of **150 KLD** and shall be good for meeting the treated parameters requirement as follows:
 - a. Permissible limit as prescribed in IS:2490 (Part-I) – 1974 and environment(Protection)Rules 1986.
 - b. Water (Prevention and Control of Pollution) Act, 1977 & 1978.
 - c. Environment (Protection) Act, 1986.
 - d. Environment (Protection) Rules, 1986.
 - e. Hazardous Wastes (Management & Handling) Rules, 1989.
 - f. Manufacturer, Storage and Import of Hazardous Chemicals Rules, 1989.
 - g. Manufacturer, use import and storage and hazardous Micro-Organizers, Genetically Engineered organizations or Cell Rules, 1989.
 - h. Manual on sewage & sewage treatment - CPHEEO
 - i. The Public Liability Insurance Act, 1991.
 - j. All standards as laid down by Central Pollution Control Board and anyother relevant statutory authority.
 - k. 100% recycle of wastewater and removed of sludge with no water to bedischarged outside the premises.

10.2 SEWAGE TREATMENT PLANT

1. GENERAL

The sewage treatment plant (STP) system outlined in this section specifies the system design, manufacture, supply and installation of a **Moving Bed Bio Reactors (MBBR) System with Ultra Filtration system.**

The contractor working according to the above given technology and meet the standard acceptable parameter to water and sanitation authority requirement, local pollution control board norms, World Health Organization guidelines, the local environmental and pollution control authorities and subject to the approval of EIC.

The work shall be carried out in a manner consistent with good practice in the local market. The Contractor shall take into account all site conditions in designing the system and selecting the equipment.

The Contractor shall be responsible for engaging a STP specialist to perform the system design and obtain approval from relevant Authorities. A qualified and experienced Engineer shall be engaged for the system design, preparation of system proposal submission, obtaining approval and site supervision.

The Contractor shall perform the system design based on the criteria/data and component technical requirements specified in this section/drawings and the local Authorities' regulation/requirement.

The Contractor shall furnish system which comprises products of manufacturers who have designed and made these associated products for a period of at least five years.

The Contractor shall submit complete catalogue information, design calculation and samples complete with full technical data and shop drawings for the entire system, test certificates, etc. for acceptance prior to commencement of installation.

The Contractor shall submit analytical test reports of effluent water samples after the commissioning or after the system is put into operation or as required by the EIC:

The report shall contain analysis of all data related to those requirements laid down by the local Authorities.

As a minimum the following items shall be measured and analyzed/ as indicated under clause 2.1 following.

2. **DESIGN CRITERIA**

- 2.1** It shall be the Contractor's responsibility to ensure the quality of the treated effluent to comply with the local Authorities requirement and the following characteristics, whichever is stringent.

Desired Effluent Characteristics after Treatment

a.	pH	:	6.5 to 9.0
b.	Total suspended solids	:	< 10 mg/l
c.	BOD	:	< 10 mg/l
d.	COD	:	< 50 mg/l
e.	Oil & Grease	:	< 10 mg/l
f.	Phosphate (PO ₄)	:	<1 mg/l
g.	NH ₄ -N	:	<5 mg/l
h.	N total	:	<10 mg/l
i.	Fecal coliform(MPN/100ml)	:	<100

The treated effluent will be odorless, free from oil, grease and other obnoxious matters. Equipment for all modules shall be placed in a common STP plant room.

2.2 ***Description of Process***

The treatment process shall comprise the following stages:

- Physical treatment: Mechanical coarse and Fine bar-screening
- Primary treatment: oil and Grease Skimmer
- Equalization tank: flow equalization with air mixing
- Flow measurement: flow meter
- Biological treatment: MBBR Technology and Tube settler
- Water reclamation: Tertiary filtration, Ultra-filtration Membrane &sterilization
- Sludge Treatment: Centrifuge

2.3 Performance Criteria of the Plant

Raw sewage will be brought into the Sewage Treatment Plant. The Contractor shall receive sewage from this point to the treatment plant for treatment process. The treatment process is aimed to convert the influent quality as mentioned above, into the required quality standards so that the treated effluent can be re-used for non-potable use specified above. It is proposed to perform the treatment of the effluent by the biological aerobic process. The process is designed to induce the growth of bacteria, which by physical and physio-chemical action retain the organic pollution and live on it. This growth is obtained by putting a bacterial culture disposal as a flock in the aeration tank.

To have an efficient treatment system, this aeration system is proposed consisting of Moving Bed Bio film Reactor Tank.

Treated effluent shall be connected to a tertiary filtration & Ultra Filtration treatment and shall be treated for use for flushing & irrigation purpose. The Contractor shall carefully consider the operation loading for the Sewage Treatment Plant.

2.4 Process Description

The Contractor shall design the Sewage Treatment Plant to receive continuous sewage inflow within the plant room allocated on the site plan. The ease of maintenance and operation is of utmost importance in the design of Sewage Treatment Plant.

The Contractor can propose suitable sewage treatment methods like standard aeration with floated media sewage treatment plant, differential flow-floating sludge system, etc. The design of the Sewage Treatment Plant shall be such that it can be installed within the allocated space and shall be subject to the approval of the EIC.

2.4.1 Inlet Screen Chamber:

Raw sewage shall flow into the 2 No. Inlet coarse and Fine bar screen chamber by gravity. Large solids particles shall be intercepted by an fine step screen. A manual 10-12 mm screen shall be installed in parallel with the screw screen as a standby screen when the step screen is under maintenance. The Oil and grease separate and grit collection chamber shall be provided with mechanical oil skimmer

2.4.2 Oil and Grease Chamber:

Sewage comes from the bar screen chamber to oil & grease chamber by gravity. The solids and fats that are separated in this unit are disposed of along with other biodegradable waste, and can be used as feed for piggeries. The heavier grit and solids sink to the bottom of the tank. The baffle plate prevents the floating fat and scum from drifting towards the outlet.

2.4.3 Equalization Tank:

The sewage from the oil, grease chamber comes to the equalization tank. The equalization tank is the first collection tank in an STP. Its main function is to act as buffer: To collect the incoming raw sewage that comes at widely fluctuating rates, and pass it on to the rest of the STP at a steady (average) flow rate. During the peak hours, sewage comes at a high rate. The equalization tank stores this sewage, and lets it out during the non-peak time when there is no/little incoming sewage. Compressed air comes through this air supply pipeline. The coarse bubble diffusers are disc type that have holes at regular spacing. They release large bubbles in the tank to lightly aerate the sewage, and also to agitate the mix continuously.

2.4.4 Anoxic Tank:

Sewage comes from equalization tank by the help of submersible pump installed in the equalization tank generally known raw sewage transfer pump. This tank made only for removing the ammonia from the sewage. It is designed only for 1 – 1.5 times of average flow.

Anoxic zones are used to facilitate denitrification using bacteria to convert nitrates to nitrites and finally to nitrogen gas which is released from the basin. Agitation will be done through anoxic mixer which is required to blend the basin contents to increase process efficiencies.

2.4.5 MBBR Tank (Aeration Tank) with Floating Media: (2 nos. Tank)

From the anoxic tank sewage comes into the aeration or MBBR reaction tank. It is at the heart of the treatment system. The function of this tank is to maintain a high population level of microbes. This mixture is called MLSS (Mixed Liquor Suspended Solids).

The baffle wall does not let the incoming sewage and sludge go across the tank toward the outlet pipe. The wall forces the mix toward the bottom of the tank; thus ensuring maximum retention. The tank is always filled till this level. The Outlet Launder collects the sewage and delivers it to the outlet pipe. The fine bubble diffusers are actually rigid pipes with long slots, which are then covered with tubular silicon rubber membranes. The compressed air is released in the form of fine bubbles throughout the length of the diffusers, through minute holes punched in the rubber membrane. An array of eight diffusers. The array is strapped to cement blocks (ballasts) to keep the entire assembly anchored to the bottom of the tank. In the case of fixed diffusers, compressed air is supplied through a header pipe at the bottom of the tank. Some designs use flexible air hose lines and pairs of diffusers to make them easily retrievable. In this case each pair of diffusers is also provided with a nylon rope to enable lifting out of the aeration tank for maintenance.

The recirculated sludge pipeline brings bacteria floc from the settling tank/secondary clarifier. It is always located very close to the inlet pipe so that the raw sewage and bacteria get mixed thoroughly.

2.4.6 Secondary Clarifier/ Settling Tank:

The sewage after bio-oxidation shall enter the rectangular flat bottom sedimentation tank where the sludge effectively settles to the tank bottom. The clear effluent shall weir into the chlorination chamber.

The activated sludge collected in the sludge tank shall be returned to the aeration tank for further oxidation of the incoming organic matter by means of automatic siphoning / pumping. SS Excessive sludge shall be wasted in the sludge holding tank.

Any scum formed on the surface of the clarifier tanks shall be returned to the aeration tank by automatic siphoning / pumping.

The sewage inlet pipe brings sewage from the aeration tank. The center-feed well takes this incoming sewage and gently releases it in the settling tank, without causing any disturbance or turbulence. The well is always filled with water because of its position. So the incoming sewage does not drop from a height and disturb the sludge that is already settling toward the bottom of the tank. The sludge is only slightly heavier than water; so it takes time to sink. It slides down the steeply sloped walls of the tank toward the center of the bottom. The bacterial flocs collect here in high concentration. Even when the flocs settle at bottom, they actually remain suspended in water, rather than forming a solid sediment.

2.4.7 Chlorine Contact Tank:

A chlorine contact tank with a capacity of not less than 2 hours average flow detention shall be furnished. It shall be attached to the settling tank. Construction shall be similar to the other tanks and panels comprising the treatment plant, and shall include flow diversion baffles and outlet of the chlorine contact chamber for measuring the waste flow.

A chlorine feed system shall be furnished as a complete package assembly for installation in the plant room. Assembly shall include base plate, electronic positive displacement type chemical feed pump, fiber glass solution tank, suction and discharge tubing and fittings.

2.4.8 Ultrafiltration Tank:

Ultrafiltration system used in the STP only for achieve Bod less 5 mg/l. water took from the chlorine contact tank and passed through the ultrafiltration system by the help of pumping and stored the water into the ultrafiltration tank. It is designed only for 1 – 1.5 times of average flow.

2.4.9 Flushing Tank including irrigation water requirement:

A flushing tank is made in the rectangular form with flushing capacity including irrigation capacity of one day. Treated water comes from ultrafiltration tank by the help of filtration system and stored in the flushing tank. Flushing water supply to the building by the help of hydro pneumatic system. On this line UV unit installed for deactivate the bacteria's.

2.4.10 Sludge Holding Tank:

Excessive sludge shall be stored in the sludge holding tank for final dewatering and disposal. It is designed only for 1 times of average flow.

2.4.11 U.V. Sterilizer with Monitoring Arrangement

Quartz based U.V. Sterilizer shall be designed to provide a UV Dose of 600 J/m² at UVT of 65% and TSS less than 10 mg/L. System should deliver a 4 log reduction of total coliforms. The electrical control system should utilize high frequency electronic ballasts and provide efficiency of more than 90%. The reactor vessel shall utilize internal baffles to ensure turbulent and plug flow.

The UV intensity monitoring system shall be designed in accordance with the German DVGW W294 standard. The sensor shall be of dry type and removable without system shutdown.

3. EQUIPMENT

The following give the minimum requirements of the different components of the system. It shall be the Contractor's responsibility to select equipment for the plant proposed by them so that the capacities and performance of the Sewage Treatment Plant meet with the criteria set out in this specification.

All equipment and components of the system shall be of top quality construction and shall be corrosion resistant.

3.1 Coarse Screening Equipment

Bar screen shall be of SS 316 stainless steel construction. Drip trays shall be provided for holding and drainage of the screenings. A manual by-pass screen of 30mm opening with stainless steel drip tray shall be provided. An isolation valve shall be provided to divert the flow to the bypass screen when the screen require service.

3.2 Air Blowers

Air blowers shall be provided in duplicate / Triplicate, with one standby. Blowers shall be either of positive displacement or centrifugal with pressure vessel type complete with VFD controlled motor, base-plate, inlet filter, intake silencer and off-load starting system outlet silencer, anti-vibration damper, flexible coupling, filter restriction indicator, non-return valve, pressure relief valve, V-belt system or direct drive coupling. The casing rotor shall be of cast iron construction. Bearings and gears shall be grease lubricated. Motor speed shall be 1500 rpm.

The size and performance of the air blower shall be so selected that it can provide a minimum air flow rate 0.5 l/sec / diffuser to 1l/sec/diffuser maximum, and to maintain a minimum of 2.0mg/dissolved oxygen in the aeration tanks in operation.

3.3 Air Diffusers for Aeration Reactor Tanks

Air diffusers shall be made to provide a uniform distribution of fine bubble air release performance in the system. The air diffuser shall be either made of elastomeric rubber membrane or composed of crystalline fused aluminum oxide with a suitable ceramic bonding material.

Membrane endurance shall be more than 180,000 expansion/contraction cycles.

Diffuser shall be of self-cleaning, non-clog disc or dome-shaped type. Oxygen transfer efficiency shall not be less than 20% at 3.5m submergence in clear water. Alternatives may be offered for consideration.

Diffuser hold down assemblies shall consist of a retainer bolt, a matching washer and gasket. Sealing gasket shall be composed of solid neoprene rubber and shall conform to ASTM D-2000 and shall be suitable for withstanding the effects of wastewater high temperature up to 120 C°.

The Contractor shall submit calculation to justify the diffuser selection and air requirement during the detailed design.

3.4 *Raw Sewage Transfer Pump (2w+1s):*

It is used for transfer the sewage from equalization tank to anoxic tank / Mbbf tank. It's a submersible pump speed upto 2900 rpm, C.I. impeller and C.I. Body, connected to a TEFC motor suitable to handle solids upto 50 mm size with mechanical seal suitable for 400 / 440 volts, 3 phase 50 cycles A.C. supply.

3.5 *Sludge Collectors:*

The sludge collectors serve to scrape the settled sludge to the sludge pump pit and a skimmer shall collect the scum. Each shall be of mechanical drivers for full automatic operation.

All components such as chain, sprocket, etc. inside the tank shall be made of non-metallic material (such as cast nylon).

3.6 *Sewage Pumps*

Working and standby sewage pumps shall be provided. Each shall be of submersible type c/w guide base to facilitate ease of removal, lift chain and automatic discharge connection. Pump casing and impeller shall be of cast iron material. Shaft shall be of stainless steel material.

3.7 *Final Settling Tank:*

Settling tanks shall include baffles to prevent short circuiting.

Sludge withdrawal shall be by means of rotating sludge collectors. submersible sludge pump shall be installed in the hopper bottom at inlet side of the settling tank for periodic sludge removal.

3.8 *Disinfection*

High Flow U.V. Sterilizers shall be installed in the outlet side of filters before the treated water enters the treated water tank.

3.9 Chlorination System

A chlorine contact tank with a capacity of not less than 2 hours average flow detention shall be furnished. It shall be attached to the settling tank. Construction shall be similar to the other tanks and panels comprising the treatment plant, and shall include flow diversion baffles and outlet of the chlorine contact chamber for measuring the waste flow.

A chlorine feed system shall be furnished as a complete package assembly for installation in the plant room. Assembly shall include base plate, electronic positive displacement type chemical feed pump, fiber glass solution tank, suction and discharge tubing and fittings.

Each chlorine solution dosing pump shall perform to achieve a residue not more than 1 mg/l in the treated sewage. Solution feed pump shall have a maximum capacity of 1 l/hr. chemical pump will operate on 50 Hz supply. Fiber glass solution tank shall be of no less than 100 liter capacity and include suction line fitted with strainer.

Control shall be by means of compound loop (i.e. flow proportional and residual measuring).

The feed pump shall be of variable speed positive displacement, solenoid-driven diaphragm metering type. The construction material shall be suitable for corrosive nature and as follows:

3.10 Tertiary Treatment

This tertiary treatment shall be provided for the effluent used for flushing & irrigation purpose.

The tertiary treatment plant shall comprise of the pressure sand filters and activated carbon filters, softeners (as per water quality) etc. This shall be sized to accommodate 100% of the effluent discharge flow rate and shall achieve the performance as outlined and described in Design Criteria.

3.11 Treated Water Transfer Pumps

Working and standby Treated Water Transfer pumps shall be provided.

Pump casing and impeller shall be of cast iron material. Shaft shall be of carbon steel material.

3.12 MOTOR CONTROL SYSTEM

EPC shall be designed WTP panel as per actual ratings and submit to Engineer In Charge for approval before fabrication, also provide logic controls. For switchgear, rating / panel specification please refer electrical specification.

The main switchboard shall be floor mounted, free standing, cubical type, compartmentalized and shall be factory built fabricated by one of the approved switch board manufacturer. The board shall be fabricated from 2mm thick CRCA sheet and powder coated after seven tank process. The board shall be fabricated with IP 54 degree of protection suitable for operation of 415 volt \pm 10%, 3 phase, 4 wire, 50Hz, AC supply. The switch board shall have provision for termination of cables from top as well as

bottom with suitable knockouts. The layout shall be designed for convenient connections and inter-connections with various switchgears. Connections from individual compartments to cable alleys shall be such as not to shut down healthy circuits in the event of maintenance work becoming necessary on a defective circuit. A base channel of 75mm 5mm thick shall be provided at the bottom. A maximum of 200mm space between the floor and bottom most panel of unit shall be provided. The bus bar shall be of aluminium complete with heat shrinkable PVC sleeves. The fabrication of switch board shall be taken up only after the drawings for the fabrication of the same are approved by the AAI.

Control panel shall contain starters and safety protection for all pump controls etc. It shall also house the switchgears for incoming as well for outgoing supply. Provision of voltmeter (for incomer) & ammeter for incomer as well as for measuring the current drawn by each motor with selector switch, a set of LED indicating light for incoming phases as well as status indication of each equipment. The voltmeter & LED indication lamps shall be protected by MCBs.

All the motors shall be provided with fully automatic Star Delta/DOL starters with motor duty MCCBs for short circuit protection only (ICS = 100% ICU) & Overload Relays with contactors of suitable range & ratings for overload protection. Single phase preventers shall be provided for all 3 phase motors. Single phase preventer shall be in conformity with relevant ISI standards. Single phase preventers shall act when failure of one or more phases. Single phase preventer shall be voltage operated and of approved make.

The MCCB for incomer shall be with Thermal magnetic release & should provide adjustable setting for overload and short circuit protection with ICS = 100% ICU.

Interlocking shall be provided between switch and the door in such a way that the door of the panel cannot be opened when the supply is ON.

The panel shall be provided with all identification tags, danger board etc as per standard. All control panels shall be provided with detailed control circuit diagram indicating the terminal numbers and color coding of the wires used in the panels. This diagram shall be pasted on the inner side of the cover and protected with PVC transparent lamination.

For detailed specification of switchgears & accessories, specifications under electrical sub head of contract shall be considered.

All pump control panels shall be compatible with BMS system.

4. POWER CABLING

Contractor shall provide all power /control cables from the motor control centre to various motors, level controllers and other control devices. All power cables shall be aluminum conductor XLPE insulated armored and PVC sheathed and control cables of copper conductor PVC insulated armored and PVC sheathed. All Power / Control cables shall have FRLS outer Sheath and stranded conductors of 1100 Volt grade. The cables shall be in drums as far as possible and bear manufacturer's name.

Specification of cable laying shall be followed as described in Internal EI package of this tender.

5. CABLE TRAYS

Specification of cable trays shall be followed as described in internal electrical package of this tender.

6. EARTHING

Main Electrical power upto the Electrical panel(s) in water supply Pump Room along with earthing shall also be considered in the scope.

All three phase motors / equipment shall be earthed with two independent earth conductors as per the requirement of Indian Electricity Rules and Regulation - 1956. Earthing specifications shall be followed as described in Internal EI package of this tender.

7. PUMPS FOR HYDROPNEUMATIC & DRAINAGE SYSTEM

7.1 PUMPS (HYDROPNEUMATIC)

Pumps shall be vertical, centrifugal, multistage directly coupled to motor. Provision of pump with pump head & base of cast iron and other parts in SS 316 shall be made for pumps required in Hydro Pneumatic System. Impeller shall be hydraulically balanced and keyed to shaft. Pump shall be mounted on a concrete foundation, projecting at least 15 CM above finished floor level. The pumps base shall be set on a vibration elimination pad. The pump shall be lubricated in strict accordance with the manufacturer's instructions and shall be factory aligned prior to shipment. All motors and bases shall be painted with approved finish shop coat of paint. The pump shall be selected for the lowest operating noise level and shall be complete with flexible connections, valves, and pressure gauges. The pumps shall include cost of foundation channel complete.

The Contractor shall supply and install pumps of the type and performance as shown on the drawings. All duties of pumps given in the performance curve Drawings shall be checked and where necessary corrected before ordering. All the parts of the pumps that are in contact with water e.g. shaft, impeller etc. shall be of stainless steel construction.

Pumps shall be so selected that the design duty point is within 5% of the maximum efficiency point. The pump casing so selected shall have ample space to take an impeller one size larger than that capable of performing the design duty.

The pump shall have a speed of not more than 1500 rpm. However, pumps of 2900 rpm with high efficiency and low noise motor can be selected and noise data submitted for approval. All pumps and motors shall be of minimum vibration and noise level during operation. Vibration isolators shall be provided for all pump sets. Facilities shall be provided to prevent starting of pumps when the water tank is at low water level. An indicator for this low water level alarm shall be provided.

Facilities to select which pump to be duty pump and standby pump shall be provided and be interchangeable.

Leakage from pump gland shall be drained to the nearest floor waste.

Pump curves for all pumps offered shall be submitted. All curve indicating excessive shut-off head will not be approved.

Each pump shall be provided with a gate valve at suction and discharge, approved. check valve at discharge, approved strainer at suction, flexible connections at pump suction and discharge, eccentric reducer at suction, concentric reducer at discharge, pressure gauges at suction and discharge, circulation relief valve and automatic air relief valve.

Appropriate neoprene vibration isolation mountings shall be provided for each pump sets. Vertical Multi-Stage Pumps

Multi-stage pumps shall be of centrifugal type and arranged with shafts vertically installed. The impellers shall be of stainless steel mechanically balanced and keyed to shaft. Renewable guide rings are to be provided in the casting, keyed to prevent rotation. Pumps shall be driven by elevated in-line TEFC squirrel cage motors via extended vertical shafted complete with universal couplings.

The shafts shall be stainless steel. Stainless steel sleeves shall be provided to protect the shaft in the water space and through the sealing glands. The sleeves shall be keyed to prevent rotation and secured against axial movement.

The bearings shall be of ball or roller type protected against ingress of water, dirt and other matter.

Vertical multistage pumps shall have universal flanges. Intermediate bearing, support bearing shall be provided in the pump.

The shaft seal shall be easily serviceable and shall allow for correct adjustment and loading of the seal. Pump motors above 7.5 kW shall be equipped with a spacer coupling which allows changing of shaft seals without removing the motor. The pump motors shall be of Class "F" insulation and IP55 rating and shall be provided with built-in thermistors for protection against overheating.

7.2 Sump Pump Submersible

These shall be fully submersible with a fully submersible motor. The pumps shall be provided with an automatic level controller and all interconnecting power and control cabling which shall cause the pumps to operate when the water level in the sump rises to a preset level and stop when the preset low level is reached.

Pumps for drainage shall be single stage, single entry.

Pump shall be C.I. casing and C.I. two vane open type with a dynamically balanced impeller connected to a common shaft of the motor. The vane for sewage pump will be open type, while for drainage pump, etc. it will be of semi open type. The MOC of the sump shall be in accordance to schedule of quantity.

Stuffing box shall be provided with mechanical seals.

Each pump shall be provided with a suitably rated induction motor suitable for 415 volts, 3 phase, 50 Hz A.C. power supply.

Each pump shall be provided with in built liquid level controller for operating the pump between predetermined levels.

The pumping set shall be for stationary application and shall be provided with pump connector unit. The delivery pipe shall be joined to the pump through a rubber diaphragm, and bend and guide pipe for easy installation.

Pump shall be provided with all accessories and devices necessary and required for the pump to make it a complete working system.

Sump pump shall be complete with level controllers, power and control switch gear, Auto/off/Manual switches, pumps priority selections and control and power cabling upto motor and controller/probes etc. (Including earthing). Level control shall be such that one pump starts on required level, 2nd pump cuts in at high level and alarms is given at extra high level. All level controllers shall be provided with remote level indications.

7.3 Motor Design

The pump motor shall be a squirrel cage induction, housed in air filled water-tight enclosure. Oil filled motors are not acceptable. The stator windings shall be Class "F" insulation (155 degree C or 311 degree F) for general usage and class 'H' insulation (180 degree C or 317-8 grade 2) for submersible type.

The stator shall be heat shrunk fitted into the enclosure and shall not use bolts, pins or other fasteners that penetrate through the stator enclosure. The starter shall be equipped with a thermal switch embedded in series in the coils of the stator windings to protect the stator from wheel.

The motors shall be designed for continuous running duty type at 415 volts, 3 phase, 50 Hz power supply and capable of sustaining a minimum of 20 starts/stops per hour.

Between stator housing and pump, a tandem seal arrangement will be provided with an oil barrier. Both seals run in oil, allowing dry running without seal damage. Both seals shall be of the rubber bellows or metallic bellow type with positive drive between shaft and rotating seal face.

7.4 Other Equipment

Any other necessary accessories, such as buffer, riser, decanting system, partition, control panel, collection devices, etc. for all the tanks and pumps (where necessary) shall be provided in order to provide a fully working systems.

7.5 Piping Materials

SS 316 - Submerged air piping
 MS epoxy coated - Air piping and pumped effluent riser (Non submerged)
 PVC piping - Pumped effluent (submerged) & tank overflow pipe line.
 PVC - Interconnecting pipe line after delivery header of pump/filter.

7.6 Valves

The Contractor shall supply and install all isolating valves and control valves as indicated on the drawings and as required for the proper and efficient operation and maintenance of the entire systems.

All valves supplied shall be suitable for the working pressure and test pressure of the system as specified elsewhere in this specification.

Regulating valves shall be of similar materials as that specified for cast iron gate valves.

All regulating valves shall be lock shield type. All valves shall be full line size.

Each valve shall have a purpose made reference number plate for label engraved or stamped indicating the manufacturer's catalogue number, pressure and temperature ratings. Valves shall be arranged so that clockwise rotation of the spindle will close the valve.

Furnish all valves and accessory materials necessary in the piping whether or not shown on drawings as flows.

All valves shall be packed with an approved packing and threads shall be coated with oil and graphite. Packing should be replaced when found deteriorated on site.

Where possible locate all valves at convenient positions of operation from the floor with valve stems upright.

Valves that are flanged shall have flanges to the table specified for the pipework.

Plastic or metal plates (rust less) shall be provided to indicate the open / close status as well as the use of each valve in the pump and tank rooms.

Imprudence clause of pipe support here.

8. **PIPE SUPPORTS**

General Support

The Contractor, on the award of the work, shall prepare detailed working drawings, showing the cross-sections, longitudinal sections, details of fittings, locations of isolating and control valves, drain and air valves, and all pipe supports.

Piping shall be properly supported on, or suspended from, on stands, clamps, hangers as specified and as required. The Contractor shall adequately design all the brackets, saddles, anchor, clamps and hangers, and be responsible for their structural stability.

Pipe work and fittings shall be supported by hangers or brackets so as to permit free expansion and contraction. Risers shall be supported at each floor with Galvanised steel clamps. To permit free movement of common piping support shall be from a common hanger bar fabricated from Galvanised steel sections.

Piping shall be supported from the building structure, which shall support the sum of the load of a water-filled pipe and a minimum of 120 kg applied at the point of hanging.

All piping brackets shall be constructed as per the drawings approved by AAI. Vertical pipework shall be supported at intervals of at least one per floor level.

Horizontal pipework shall also be supported by adjustable flat iron or clevis type hangers hung by hot rolled steel rods of the following diameters and spacing subject to the Architect's approval:

<u>Nominal Pipe Size</u>	<u>Distance between Supports</u>	<u>Diameter of Rod</u>
25 mm	1.8 m	10
32 mm	2.4 m	10
40 mm	2.7 m	10
50 mm	2.7 mm	10
65-80 mm	3.0 m	12
100 mm	3.0 m	16
150-200 mm	3.6 m	18

The end of the steel rods shall be threaded and not welded to threaded bolt.

Hangers shall be supported by means of approved fasteners. Wood plugs shall not be used. Unless allowed by the structural engineer, power fixings may be used for pipework of diameter less than 50 mm. Expansion fasteners may be used for vertical pipe work under 100 mm diameter.

All pipe work shall be carried out in a proper workman like manner, causing minimum disturbance to the existing services, buildings, roads and structure. The

entire piping work shall be organized in consultation with other agencies work, so that area can be carried out in one stretch.

Requirement of Cut-outs in the structural slab or wall for installing the various pipes shall be clearly identified in the detailed shop drawing to be prepared by the STP contractor.

Pipe sleeves, larger diameter than pipes, shall be provided wherever pipes pass through walls and slab and annular space filled with fiberglass and finished with retainer rings.

The contractor shall make sure that the clamps, brackets, saddles and hangers provided for pipe supports are adequate or as specified / approved by Consultants. Piping layout shall take due care for expansion and contraction in pipes and include expansion joints where required.

All pipes shall be accurately cut to the required sizes in accordance with relevant BIS codes and burrs removed before laying. Open ends of the piping shall be closed as the pipe is installed to avoid entrance of foreign matter. Where reducers are to be made in horizontal runs, eccentric reduces shall be used for the piping to drain freely. In other locations, concentric reduces may be used.

Automatic air valves shall be provided at all high points in the piping system for venting. All valves shall be of 15mm pipe size and shall be associated with an equal size gate valves.

Discharge from the air valves shall be piped through a pipe to the nearest drain or sump. All pipes shall be pitched towards drain points. Pressure gauges shall be provided as shown on the approved drawings. Care shall be taken to protect pressure gauges during pressure testing.

9. INSTALLATION

The Contractor shall check the associated civil work prior to the installation of any item of machinery and advise the EIC, in writing, of any deviation of such work from the specified details.

The machinery shall be accurately installed to correct dimensions, alignments, levels, etc., all as indicated on the final drawings. The machinery shall be mounted on flat steel packing pieces of thickness suitable to take up variations in level of the concrete foundations. Suitable packing pieces shall be located adjacent to each holding down bolt and shall be properly bedded by grinding the concrete surface to a smooth, level finish. The machinery shall be aligned and levelled and the nuts of the holding down bolts tightened with a spanner of normal length. The base plates shall be packed with grout after the machinery has been run and checked by the EIC for stability and vibration.

Installation shall include the provision and fixing of all necessary holding down bolts, washers, nuts etc.

The length of all bolts shall be such that when fitted with a nut and tightened the threaded portion of the bolts shall protrude from the top face of the nut by a distance not exceeding half the bolt diameter. Exposed bolt heads and nuts shall be hexagonal.

All equipment and materials of the same type shall be products of the same manufacturer. Locally made equipment will not be accepted unless otherwise specified.

All similar items of plant and their component part shall be completely interchangeable. Spare parts shall be manufactured from materials similar to the originals and shall fit all similar items of plant. Where machining may be needed before fitting renewable parts, the machining fits with their tolerance shall be shown on the drawings accompanying the instruction manuals.

All motors and/or revolving parts shall be truly balanced both statically and dynamically so that when running at normal speeds and any load up to the maximum there shall be no significant vibration due to lack of balance. All parts which can be worn or damaged by dust shall be totally enclosed in dust-proof housings.

10. PIPE PROTECTION (FOR COLD WATER PIPES BURIED IN TRENCHES / GROUND / EARTH)

All buried pipes shall be cleaned with zinc chromate primer and bitumen paint, wrapped with three layers of fiber glass tissue, each layer laid in bitumen and placed on concrete blocks with PUF saddles dipped in bitumen at every 2 meters. The pipes where laid under floor shall be encased with 100 mm thick jamuna sand all around in addition to protective coating as described above.

11. TESTING

The performance of the system shall be demonstrated by taking hourly samples of the raw sewage and final effluent over a twelve hour period. The sample shall be taken at periods approximately the flow rates specified by the plant. The sample shall be combined and a 5-day BOD shall be run, the results of which must verify the capacity of the treatment plant prior to acceptance.

10.3 SECTION-3: TESTING, COMMISSIONING AND HAND OVER

1. GENERAL

The entire works included in this Contract shall be fully tested in stages as the work proceeds and on completion of work as applicable.

The Contractor shall provide during normal working hours, all necessary labours, instruments, equipment, materials, fuel, power and maker's representatives, to carry out such tests as may be necessary to satisfy the Architect that the installation meets the requirement and intent of the Specification as well as such tests required by Local Authorities.

All tests shall be made in the presence of the Architect or his representative or any inspecting authority. At least seven working days' notice in writing shall be given to the inspecting parties before performing any test.

Three copies of all test results shall be submitted to the Engineer in A4 size sheet paper within two weeks after completion of the tests.

Tests described hereinafter and including all tests prescribed by the Authority having jurisdiction shall be carried out. Any tests proved unsatisfactory shall be repeated to the satisfaction of the inspecting parties.

The Contractor shall provide skilled technicians/engineer to commission the plant and associated controls to the satisfaction of the Architect. The technicians/ engineers will be required to demonstrate the correct procedures in starting and stopping the plant, running the various items of equipment under automatic and manual control and the correct maintenance of the plant.

Water flow rates of all equipment shall be adjusted to design conditions. Complete results of adjustments shall be recorded and submitted.

2. ON-SITE TESTING AND COMMISSIONING

Two months prior to completion of the Contract Works, the Contractor shall liaise with the Main Contractor and the Electrical Contractors and submit for the Architect's approval a detailed programme for conducting on-site acceptance tests and commissioning.

The Contractor shall start up, operate, test and adjust the systems in accordance with the agreed programme. The setting shall be supervised by the manufacturer's representative, who shall remain on site until the equipment is operating satisfactorily and accepted by the Architect. The Contractor shall advise and co- ordinate with the manufacturer's representatives so that all testing is carried out

according to the agreed programme.

The whole installation shall be given the following tests to bring the systems into running order. The Architect shall be given reasonable notice together with a copy of recorded test results, generally not less than seven (7) days, regarding the nature of tests, the time and location. Acceptance tests will only be witnessed by the Architect when the submitted test results are found satisfactorily.

All instruments, tools, material and labour required to perform these tests shall be provided by this Contractor.

Before the tests are carried out, the Contractor shall remove connected equipment and components which are liable to damage under test, and shall provide and fix all the necessary gauges, blanking flanges, etc.

Prior to the system start-up, the following inspection, tests and pre-commissioning treatment shall be carried out by the Contractor:

a. Tanks and Level Switches

Check sides and edges of sectional tanks for distortion. The tanks shall be thoroughly cleaned with water and drained before city mains supply will feed in.

Also before city mains supply will feed in, the level switch shall be simulated for the various cut-in and cut-out settings.

b. Pressure Switches

The testing equipment arrangement for pressure switches and pressure gauges shall be as shown on the drawings or of an approved equivalent.

The pressure gauges to be tested shall be connected as shown on the drawing in lieu of the pressure switch. The gauges to be tested shall be regarded acceptable when the pressure readings of all three gauges are the same throughout the jacking pressure range varied by applying the hand pump.

c. Hydrostatic Tests

All parts of the water circuit shall be filled with water before hydrostatic pressure testing, and pump running tests for verification of pressure and flow rate, are conducted.

The hand jacking pump shall be applied to increase the system pressure to 2 times the working pressure or 1.5 times the working pressure plus 3.5 bar whichever is the lower but in any case not less than 7 bar. The pressure shall

be maintained for a period not less than 24 hours.

Where any section of pipework or equipment is found to be unable to withstand the maximum pipework test pressure, it shall be isolated during the pipework test then that section of pipework or equipment shall be made good and re-tested at the appropriate test pressure.

The working pressure for various systems shall be as shown on the drawings.

- d. House drains shall be hydrostatically tested to a water head of 1.2 m at the high end and not more than 2.4 at the low end and shall show no appreciable loss of water after elapse of two hours.

In every test, water used shall be left in the pipes until they are covered with earth or other trench filling material to a depth of at least 1 m over the top of pipes and until permission is given by the Architect for the water to be released. If after the Architect has approved the sewer or pipeline and has given permission for the trenches to be refilled the pipes become damaged and loses water from any cause and/or admit subsoil water, the Contractor shall uncover the pipes and make good the defect made good and the pipes retested as before and all at the Contractor's expense.

- e. Cleaning, Flushing and Pre-Treatment

Prior to start-up and hydraulic testing, the Contractor shall clean the entire installation including all fittings and pipework and the like after installation and keep them in a new condition. All pumping systems shall be flushed and drained at least once through to get rid of contaminating materials. All pipes shall be rodded to ensure clearance of debris, cleaning and flushing shall be carried out in sections as the installation becomes completed.

All strainers shall be inspected and cleaned out or replaced.

When the entire systems are reasonably clean, a pre-treatment chemical shall be introduced and circulated for at least 8 hours. Warning signs shall be provided at all outlets during pre-treatment. The pre-treatment chemical shall:

- Remove oil, grease and foreign residue from the pipework and fittings;
- Pre-condition the metal surfaces to resist reaction with water or air;
- Establish an initial protective film;
- After pre-treatment, the system shall be drained and refilled with fresh water and left until the system is put into operation.

- Details and procedures of the pre-treatment shall be submitted to the Architect for approval.

f. Electrical Tests

Electrical tests shall comply with the current edition of IEE regulations and requirements enforced by Local Authorities.

Electrical insulation tests earth electrode resistance test and cost amenity test shall apply to bus bars, isolators and other equipment and wiring where applicable.

A 500V DC instrument shall be used to check the insulation resistance. The reading shall not be less than 1 mega-ohm in all instances.

Function simulation tests shall be performed to ensure that the systems have been installed to the control requirements as described in the Specification therein.

g. Pump Drives

The direct coupling of the pump drives shall be dismantled before the pump motor control panel is energized.

The Contractor shall demonstrate to the Architect of acceptable clearances of the coupling alignment for ensuring satisfactory power transmission.

The coupling shall not be re-mated again till the correct motor rotation has been demonstrated with power drawn from the energized pump motor control panel.

h. Pump Operating Test

The Contractor shall ensure to the satisfaction of the Architect that the installation or portion thereof which has been set to work complies with all requirements including the following:

That the plant and apparatus shall be of robust construction and of capacity for the duty specified.

That all valves, switches, controls and the like are properly regulated and capable of proper operation and in the case of valves are capable of being shut-off.

That all apparatus shall be silent.

That all instruments are correctly calibrated and read accurately.

That all services are tested in accordance with the details of the relevant clauses of this Specification.

3. STATUTORY AUTHORITIES' TESTS AND INSPECTIONS

As and when notified in writing or instructed by the EIC, the Contractor shall submit shop drawing and attend all tests and inspections carried out by Local Pollution Control Board Authorities, Water Authority and other Statutory Authorities, and shall forthwith execute free of charge any rectification work ordered by the EIC as a result of such tests and inspections where these indicate non-compliance with Statutory Regulations. Some of these tests may take place after the issue of Practical Completion of the Main Contract and the Contractor shall make all allowances in this respect.

The Contractor shall be responsible for the submission of all necessary forms and shop drawings to the Statutory Authorities which shall conform in layout to the latest architectural plans submitted to and kept by these Authorities.

The submission shall comply with the requirements set forth in the current Codes of Practice and circular letters of the Statutory Authorities. The shop drawings to be submitted shall be forwarded to the Architect for checking before submission. The Contractor shall allow for at least two submissions of complete sets of shop drawings to the Authorities, one to be made within six months after the award of the Contract but not less than six weeks before the inspection. The Architect may at his discretion instruct the Contractor for additional submissions to the Local Authorities whenever necessary.

The Contractor shall notify the Architect at least seven days in advance of his application for local Authority tests and inspections. On receipt of a confirmed date for test and inspection the Contractor shall inform the Architect without delay.

4. PRELIMINARY COMMISSIONING CHECKS

Ensure that all equipment is thoroughly cleaned, lubricated and checked for serviceability before setting to work. Particular attention is drawn to the removal of building debris from the pipe work systems.

Special attention is drawn to the need for thoroughly flushing out all pipework systems to ensure that all foreign matter is removed.

All automatic controls and safety devices shall be inspected and checked for serviceability before the working fluid or electricity is applied to the system.

5. COMMISSIONING

When the various installations have been completed and the preliminary commissioning checks carried out, the Contractor shall set to work, regulate and calibrate all system in the entire installation. Special attention shall be paid to the following items:

That all valves, switches, controls, etc. are regulated and capable of proper operation and in the case of isolation valves that they are capable of tight shut off.

That all apparatus is silent in accordance with the requirements of this Specification. That all instruments are correctly calibrated and read accurately.

That all services are tested in accordance with the details in the relevant clauses of this Specification.

Operate pumps, pressure reducing sets, etc. to ensure that all control systems are functioning correctly and are properly set, sequenced or interlocked.

6. FINAL ACCEPTANCE TESTS

Following commissioning and inspection of the entire installation, and prior to issue of the Completion Certificate, the Contractor shall carry out final acceptance tests in accordance with a programme to be agreed with the EIC.

Should the results of the acceptance tests show that plant, systems and/or equipment fail to perform to the efficiencies or other performance figures as given in this Specification, the Contractor shall adjust, modify and if necessary replace the equipment without further payment in order that the required performance is obtained.

Where acceptance tests are required by the relevant Authorities having jurisdiction, these tests shall be carried out by the Contractor prior to the issue of Completion Certificate to the acceptance of the Authorities.

7. REJECTION OF PLANT

Any item of plant or system or component which fails to comply with the requirements of this Specification in any respect whatsoever at any stage of manufacture, test, erection or on completion at site may be rejected by the authority/EIC either in whole or in part as he considers necessary/appropriate. Adjustment and/or modification work as required by the authority/EIC so as to comply with the Authority's requirements and the intent of the Specification shall be carried out by the Contractor at his own expense and to the satisfaction of the Authority.

After works have been accepted, the Contractor may be required to carry out assist in carrying out additional performance tests as reasonably required by the Architect/EIC.

8. WARRANTY AND HANDOVER

The Contractor shall warrant that all plant, materials and equipment supplied and all workmanship performed by him to be free from defects of whatsoever nature before handover to the Employer.

9. HANDING OVER OF DOCUMENTS

All testing and commissioning shall be done by the Contractor to the entire satisfaction of the EIC and all testing and commissioning documents shall be handedover to the EIC.

The Contractor shall also hand over all maintenance and operation manuals, all certificates and allother documentation as per the terms of the contract to the EIC.

SOLAR POWER PLANT

11.1 SOLAR POWER PLANT

1 SCOPE

- The scope of work includes Design, fabrication, supplying installation, testing commissioning Grid-Interactive Solar Photovoltaic system generation plant having generation capacity as per DBR using suitable rating Mono Crystalline Silicon PV cells/modules & accessories conforming to IEC 61215& IEC 61730, solar inverters, module mounting structure, mounting Clips & conforming to other standard as per technical specifications and guide line of MNRE. The same shall include SITC of PV Modules, HDGI super structure supported on GI support with inverter, Hybrid Controller with data logger, ACDB, net metering etc. battery less system and all interconnecting cabling as required, integration with grid & handing over, etc. complete as required.
- Tentative Grid-Interactive Solar Power Plant shall comply and be as per IEC 61215-2005 and IEC 61730 -1, -2 amendment up to date specifications. The system shall be complete with earthing and cabling as per CPWD General Specifications for Electrical Works Part-I (Internal) 2023 and Part-II (External) as amended up to date.
- The successful bidder shall have a System Integrator for providing an end to end Solution for the above, including but not limited to design, supply, erection, testing, commissioning of the required Solar Photo Voltaic power plant with accessories, peripherals like string inverters, cables, cable tray, ACDB, Cable termination & connections sockets& other suitable accessories, earthing, Data Acquisition & storing, Metering, DC system etc. and installation, performance testing, commissioning, warranty, annual maintenance, etc. The bidders have to ensure the planning and smooth execution of the project. The Contractor shall carry out and complete the said work in every respect as per direction of and to the satisfaction of the Engineer in charge. The work includes interfacing the PV Plant with the Grid equipment.
- The EPC to provide the Glare analysis study report.

2 SOLAR PV SYSTEM

- Design Supply, installation, testing and commissioning of Solar PV modules (inclusive of Electrical, Electronics and mechanical features).
- The installation shall include the electrical wiring, cabling, terminations, cable trays, string inverters, Central inverters, metering, Data acquisition & recording suitable clamping/installation arrangement to existing steel frame structure/terrace and hooking up the system to the electrical grid supply.
- The PV modules shall be installed with the necessary tilt with most effective orientation.
- Supply and installation circuit breakers, isolation diodes etc.
- Supply and installation of String inverters.
- Supply and installation Cables on pre-fabricated GI cable trays with covers and/ or within suspended ceiling spaces including installation, cable trays, hangers, supports, cable

terminations and all fixing accessories inclusive of PVC Sleeves/other accessories etc. wherever required for actual design.

- Supply and installation of Copper bonded chemical Earthing pits with testing joint for every earth pit.
- Solar System capacity shall be calculated as per area along with drawings. The solar system capacity shall be based on the site conditions & considering all the parameters during the operation & maintenance but not less than i.e. mentioned in DBR
- Supply, installation and Testing of entire system including synchronize with grid supply in due coordination with other agencies as involved in the projects i/c Local bodies. The Executing agency shall do connected work for integration of solar system with the grid for which nothing extra shall be paid.
- The system must be capable of logging all parameter (both A.C. & D.C.) like generated power in kW/kVA, voltage, current, Energy Solar Insolation (Electronic/Multifunctional).
- The system must be capable of upgrading at a later stage as and when required by the Deptt.
- The system must have two or more feeders from each AC DB planned.
- Supply and laying of power /control cables from PV power panel to plant room Main Solar LT panel including cables within terraces to main PV panels (AC / DC Power).
- The work shall be started after designing SPV Plant, fixing structure & arrangement according to available RCC roof/ space frame and as approved by engineer-in-charge.
- Data networking cabling as per site requirement.
- Materials and accessories, which is necessary or usual for satisfactory and trouble free operation and maintenance of the above equipment.
- Metering and protection/Isolating/earthing systems.
- Providing and fixing 25 mm dia CPVC pipe for module cleaning.
- Providing and fixing 25 mm dia flexible rubber pipe for module cleaning.
- Earthing system for PV array, DC power system, lightening protection system, AC power system, equipment, inverters etc.
- Data acquisition & recording system with remote monitoring facilities.
- All relevant drawings, data sheets, technical catalogues on each piece of equipment/ devices and routine acceptance & type test certificates to be handed over to the department.
- The bidder must have total integrated system integrator including string inverters, ACDBs and structure.

11.2 TECHNICAL SPECIFICATIONS FOR VARIOUS COMPONENTS OF SOLAR/ PV SYSTEM

1 Solar Photovoltaic Module

Standard

Solar Photovoltaic Modules shall conform to BIS/IS/ IEC/ UL/ CE specifications necessary certification from the reputed laboratory shall be provided by bidder. Electrical Features

- a) Solar Photovoltaic module array shall consist of high efficiency Solar Modules utilizing Crystalline Silicon Solar Photovoltaic cells. Solar Photovoltaic module shall be min. 500-Wp. Mono crystalline high power cells are used in the Solar Photovoltaic module. Solar module shall be laminated using lamination technology using established polymer (EVA) and Tedlar/ Polyester laminate.
- b) Each Solar module should consist of 72 to 144 Photovoltaic cells.
- c) On Solar Photovoltaic module efficiency shall be greater than 18.0%. Module shall be made of high transmissivity glass front surface with anti-reflection coating giving high encapsulation gain and hot butyl rubber edge sealant for module protection and mechanical support.
- d) All materials used must have a proven history of reliable and stable operation in external outdoor applications. Solar modules are designed to operate and perform in relative humidity up to 100% with temperatures between -10 Deg C and +85 Deg C and with stand gust up to 150km/h from back side of the panel.
- e) Sample modules and production processes employed in the manufacture of the offered module are in accordance with the requirements of IEC 61215/ IEC61730.
- f) The module frame must be made of corrosion resistant materials, which is electrolytic ally compatible with the structural material used for mounting the module.
- g) Module Junction box (weather resistant) shall be designed for long life outdoor operation in harsh environment.
- h) Degradation of power generated should not exceeding 20% of the min. rated power over the 25-year period. Efficiency of solar PV system shall be guaranteed to 90% for up to 12 years & 80% from 12 to 25 years.
- i) The solar modules shall have suitable encapsulation and sealing arrangements to protect the silicon cells from the environment. The arrangement and the material of encapsulation is compatible with the thermal expansion properties of the Silicon cells and the module framing arrangement/ material. The encapsulation arrangement ensures complete moisture proofing during life of the solar modules.
- j) Each module must have low iron tempered glass front for strength and superior light transmission. It also must have back sheet for environment protection against moisture and high voltage electrical insulation. The fill factor of modules is not less than 0.70 or above 70%.

- k) The peak power point voltage and the peak power plant current of any supplied module and/ or any module string (Series connected module) shall be not more than 3% from the respective arithmetic mean for all modules and/ or for all modules string as the case may be.
- l) Supply, design of reverse power protection device (relay).
- m) The solar power shall be evacuated into main LT panel in the substation at 415 volts.
- n) ESE Lightning Protection system has to be provided in accordance with IS/IEC 62305
- o) AC Surge protection device
- p) Power Evacuation permission from local DISCOM including Load Flow Study, NOC, and Permission for connection to GRID, SLD approval from DISCOM, if required & Approval for Grid Synchronization
- q) Providing and fixing 25 mm dia flexible rubber pipe for module cleaning.

2 Mechanical Features

- a) Solar Photovoltaic Module shall be made of toughened, low iron content, high transmissivity front glass. Anodized Aluminum Frame shall be provided around the module. The module shall be encapsulated with Ethyl Vinyl Acetate(EVA). Silicon edge sealant shall be provided around laminate. The back surface shall be Tedlar/ Polyester trilaminate. ABS plastic terminal box shall be provided for the module output termination with gasket to prevent water moisture the module shall be Resistant to water, abrasion, hail impact, humidity & other environment factor for the worst situation at site. Bypass diode arrangement shall be provided.

2.1 Module Mounting Structure

- The array structure shall be made of hot dip galvanized MS angles of size not less than 50mm x 50mm x 6mm size. The minimum thickness of galvanized shall be at least 70 microns. All nuts & bolts shall be made of good quality steel.
- The work should be completed with supply, fitting fixing of clamps, saddles, nut & bolts etc. While quoting the rate, the bidder may mention the design & type of structure offered. All nuts & bolts shall be made of very good quality steel.
- The quoted rate will also include the cost of necessary digging, CC foundation, back filling and restoring the surface to it's original finish as required.
- The structure shall be designed to allow easy replacement of any module and shall be in line with site requirements.
- The structure shall be designed for simple mechanical and electrical installation. It shall support SPV modules at a given orientation, absorb and transfer the mechanical loads to the ground properly. There shall be no requirement of welding or complex machinery at site.
- The array structure shall be so designed that it will occupy minimum space without sacrificing the output from SPV panels & shall withstand heavy winds.

2.2 Data Monitoring of Power Plant

Solar Irradiance : An integrating pyranometer/ solar cell based irradiation sensor(along with calibration certificate) provided, with the sensor mounted in the plane of the array. Read out integrated with data logging system/ BMS.

2.3 String Inverters

Solar array shall produce DC energy output and supplied to the DC bus for inverting to AC voltage. Maximum Peak Power Tracking (MPPT) (The efficiency of string inverters shall not be less than 98% & shall be designed to meet the Solar PV Array capacity control) will extract maximum energy from solar array and provide 415VAC +/-5% 50 HZ, to synchronize with local utility grid. Output wave shape shall be sine wave with < 3% total harmonic distortion (THD). Additionally, it will provide protection features such as, over current, short circuit, over temperature as a minimum. String inverter shall be of very high quality having high efficiency and shall be capable of running load in isolated mode. The String inverter should be completely compatible with the SPV array voltage and grid supply voltage. The String inverter shall be string type inverters to reduce the DC power losses & can have the flexibility to increase the capacity of the plant. The String inverter shall be designed for continuous, reliable power supply as per specifications. The String inverter shall have internal protection arrangement against any sustained fault. The dimension, weight, foundation details etc. of the String inverter shall be clearly indicated in the detailed technical specification. It should have user friendly for programming and view on line parameters. Unit shall be IP-65/67

2.4 Data Monitoring of Power Plant

The performance and generation data is recorded using data logger. The Monitoring system shall comprise of the following main components:

- String Inverter logs the inverter performance data and transmits the same to the Data logger.
- Data logger gathers information and monitors the performance of the inverter. It also supports measurements from the external sensors. The data can be acquired remotely via a modem.
- PC Data logging software enables automatic long- term storage of measured data from PV-Plant. It allows visualization, monitoring, commissioning and service of the installation.
- Communication interface the entire system can be operated and monitored via several interfaces (RS232/ RS485/ MPI/ Profibus/ Telephone modem/ Ethernet), in addition to the information indicated on the operator panel. Further information can also be acquired remotely through the interfaces mentioned above.

2.5 Cables and Accessories

- a. All the cables supplied shall conform to IS 694 & shall be of 650 V/ 1.1 kV grade as per interconnections, array to String inverters etc. shall be so selected to keep the voltage drop and losses to the minimum.
- b. Bidders are required to mention each size of cables used and should consider their resistance/ impedance in the design optimization. Such calculation should be submitted long with the bid.

- c. The contractor shall supply all installation accessories, which are required to install and successfully commission the power plant.
- d. Cables of appropriate size to be used in the system shall have the following characteristics:
 - i. Shall meet IEC60227/IS 694, IEC 60502/IS 1554 standards.
 - ii. Temp. Range -10 deg. C to + 80 deg. C.
 - iii. Voltage rating 660/ 1000V.
 - iv. Excellent resistance to heat, cold, water, oil, abrasion, UV radiation.
 - v. Flexible.
 - vi. Sizes of cables between array interconnections, array to Inverter etc. shall be so selected to keep the voltage drop (power loss) of the entire solar system to the minimum. The decision of the engineer-in-charge regarding sizes of the cables shall be final and binding on the contractor. The cables (as per IS) should be insulated with a special grade PVC compound formulated for outdoor use.
 - vii. Cable Routing/ Marking: All cable/ wires is to be routed in a GI cable tray and suitably tagged and marked with proper manner by good quality ferule or by other means so that the cable can be easily identified.
 - viii. The Cable should be so selected that it should be compatible up to the life of the solar PV panels i.e. 25 years.
 - ix. The ratings given are approximate. Bidder to indicate size and length as per system design requirement. All the cables required for the plant provided by the bidder. Any change in cabling sizes if desired by the bidder/approved after citing appropriate reasons. All cable schedules/layout drawings approved prior to installation.
 - x. Multi Strand, Annealed high conductivity copper conductor PVC type 'A' pressure extruded insulation or XLPE insulation. Overall PVC/XLPE insulation for UV protection Armored cable for underground laying. All cable trays including covers to be provided. All cables conform to latest edition of IEC/ equivalent BIS

Standards as specified below: BoS item / component Standard Description Standard Number
Cables General Test and Measuring Methods, PVC/XLPE insulated cables for working Voltage up to and including 1100 V ,UV resistant for outdoor installation IS /IEC 69947.
 - xi. The size of each type of DC cable selected shall be based on minimum voltage drop however; the maximum drop shall be limited to 1%.
 - xii. The size of each type of AC cable selected shall be based on minimum voltage drop however; the maximum drop shall be limited to 2 %.

2.6 Earthing and Protection

The array structure of the PV yard shall be grounded properly using adequate number of earthing kits. All metal casing / shielding of the plant shall be thoroughly grounded to ensure safety of the power plant.

2.7 Type Test

Type testing certification should be produced at the time of delivery or earlier. Type test certification should be dated not earlier than 1 year.

2.8 Installation and Commissioning

a) The bidder will also submit the erection, testing & commissioning procedure for approval to the owner. These procedures will form integral part of the acceptance report for successful erection and commissioning the system. These reports will be prepared and signed by the bidder or his representative & the officials of the Purchaser concerned with project.

2.8 Support/ Training

a) The contractor must provide complete support as per site requirement (single point of contact regarding for entire solutions). Contractor shall provide the onsite 3 day basic operation & maintenance training to owner's staff in 2 schedules or as directed by engineer-in-charge.

b) Contractor shall provide the operations and maintenance staff for first month in two shifts at site. The O&M staff provided for first month at site should be able to find the fault and repair system to maintain the desired level of uptime of solar solutions at site.

2.9 Supply, erection, connecting, testing and commissioning of following sizes of copper/ aluminum conductor XLPE armoured cables as required.

All the cables shall be supplied conforming to IS 7098 shall be of 650 V/ 1.1 kV grade as per requirement. The size of the cables between array interconnections, array to String inverter etc. shall be so selected to keep the voltage drop and losses to the minimum.

Successful Bidders are required to mention each size of cables used and should consider their resistance/ impedance in the design optimization. Such calculation should be submitted along with the bid.

The EPC shall supply, design and installation all accessories, which are required to install and successfully commission the power plant.

2.10 Earthing Kit

The array structure of the PV yard shall be grounded properly using adequate number of earthing kits. All metal casing/ shielding of the plant shall be thoroughly grounded to ensure safety of the power plant. Earthing shall be in line with IE rules. The earthing & grounding shall also meet the requirement of PV module/cell manufacturer.

Supply, installation, testing and commissioning of maintenance free chemical earthing with 10 feet rod, 50mm dia, 3.2mm thick of hot dipped galvanized G.I. Tube filled with 50x6 mm G.I.

Strip, CCM chemicals and sealed at both ends. Tube shall have double layer electrode, lead conductor welded to tube, with back fill and cast iron cover 300 x 300 mm and complete in all respects. (The installation procedures should be followed as instructed by the Earth Electrode supplier).

2.11 ACDB

AC Distribution Board suitable for outdoor (IP-54), Structure/Wall mount type construction with following items:

Low Vol Switchgear, Bus bar, LV Side incoming MCCB and number's as per EPC actual design, with CT;s tape wound type C10 and ACB/ MCCB 50kA MF type microprocessor based outgoing, Incomer 50kA ,with O/C, S/C & E/F Protection, AC SPD & Multifunction meter, RYB indicators, Multifunction meter, input output glands with enclosure

One indicating light, LED type, with R, Y, B, 230Volt AC

One no. 16A, 1Ph, socket with plug and 10A DP MCB, 10kA for 1 sec with 4sqmm.

Cable Enclosure with wall mounting arrangement for outdoor Application IP65 along with suitable heat dissipation arrangement shall be provided. Holes with glands for cable entry shall be provided.

One Set TPN Bus bar as per actual design.

Enclosure shall be Powder coated with RAL-7032 paint shade with minimum thickness Up to 65 micron. CPRI / ISO

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PUBLIC ADDRESS SYSTEM

12.1 PUBLIC ADDRESS SYSTEM

1. *General Conditions for Public Address System*

- 1.1** The offered equipment by the Contractor shall be compact, fully solid state, highly reliable and shall use latest state of the art technology.
- 1.2** The design and selection of the offered equipment by the Contractor shall be consistent with the requirements of long-term trouble-free operation with highest degree of reliability and maintainability.
- 1.3** All offered equipment by the Contractor shall be manufactured to continuously operate safely without undue heating, vibration, corrosion, electromagnetic interference or any similar problems.
- 1.4** The offered equipment by the Contractor shall be designed for continuous operation (24hours a day and 365-days a year). The design life of the equipment shall be a minimum of Five YEARS.
- 1.5** All types of spares and spare modules of the offered equipment shall be readily available with the Contractor during life-time of the equipment, for maintenance, repairs and up keep of the equipment during warranty & CAMC period, if applicable.
- 1.6** Offered equipment by the Contractor shall undertake and ensure implementation of its offered solution and shall keep its in view the safety and protection of personnel, during normal operation and maintenance or during malfunctioning of any equipment or its sub-component. This shall be ensured as an integrated feature of design, manufacture and installation of offered equipment by Contractor.
- 1.7** Offered equipment by the Contractor shall ensure adequate protection to be included for ensuring safety of personnel from any possible hazards, including EMI radiation, high voltages, etc.
- 1.8** The offered equipment by the Contractor shall furnish the details of EMI and Safety Standards met by his equipment and built-in safety features.
- 1.9** The offered equipment shall be constructed on a modular basis, using plug-in type units and components to the extent possible. Parts subject to failure, wear, corrosion or other deteriorations or requiring occasional inspection, adjustment or replacement shall be made accessible and capable of convenient inspection and removal.
- 1.10** Input and output termination cables in offered equipment shall be properly labelled to permit ready identification of the incoming/outgoing wiring.
- 1.11** All interconnecting cables in offered equipment shall also be appropriately labelled to facilitate convenient interconnection and minimize chances of incorrect connection.
- 1.12** All connecting cables required to inter-connect the equipment shall be supplied by the Contractor as a part of the offered system. All cables shall be fully assembled, connector, re-terminated and factory tested at the time of supply as part of overall system check.
- 1.13** Licenses: All Hardware system/component and Software supplied by Contractor shall be licensed, as applicable, in favor of Airports Authority of India and valid for lifetime of the offered system.
- 1.14** These are minimum specification, if tenderer provide better product & design same can be consider subject to AAI approval.

1.14.1. MAINS POWER SUPPLY

- 1.14.2.** Complete offered equipment shall operate with an un-interrupted AC power 230 Volts ($\pm 10\%$) single phase 50 Hz $\pm 5\%$. Reliable over & under voltage and over current protection circuits shall be provided in the power supply units of offered solution. The power supply units in complete offered solution shall be self protecting, and shall protect connected equipment against conducted interference, noise, voltage dips and surges & impulses.
- 1.14.3.** Mains Power Supplies used in offered solution/equipment shall be rugged enough to withstand variation in mains voltage and frequency over a prescribed time as per BIS/IS/IEC Standard so that the failures in the equipment due to power supply are minimized.
- 1.14.4.** Any specific requirement, if any, of mains power supply for the equipment is mentioned in the detail technical specification.

1.15 INSTALLATION STANDARDS

- 1.15.1.** Installation shall be carried out by technically well qualified and certified personnel as per the requirements.
- 1.15.2.** Contractors shall not outsource any part of the contract to any other vendor/third party contractor without prior permission of AAI.
- 1.15.3.** Liability, if anything, arising out of such third-party contracts to any other vendor by contractor shall be to the contractors account.
- 1.15.4.** AAI shall not be liable on behalf of contractor to any other third-party contractor/ Government of India/State/Regulatory Authorities.
- 1.15.5.** Any liabilities arising out of such third-party contracts by contractor or its men working at site shall be only to contractors' account and shall be deducted out of its running bills.
- 1.15.6.** Contractor shall submit Police Verification Certificates and obtain necessary Airport Entry Permits, for allowing its men to work at AAI restricted premises.

1.16 RELIABILITY

- 1.16.1** To ensure high availability and high reliability, the offered equipment design by the Contractor and its OEM partner shall employ the most suitable engineering techniques, materials and dependable components, field proven design and rigorous inspection during manufacturing to ensure a very high MTBO (Mean Time between Outage) and MTBF (Mean Time between Failure) of equipment.

2. ENVIRONMENTAL CONDITIONS

The Main Equipment's, Rack, Servers, UPS shall be installed in the Equipment room. Suitable size of equipment room with environment controlled, shall be made available in the Terminal building. Store and maintenance room shall also be available near/adjacent to Equipment room. Separate Power supply network shall be included in the scope of work for all PA systems, which includes input panel, output panel, distribution panel, and field DBs properly marked and follow industries standard.

The offered equipment shall can maintain its guaranteed performance when operating continuously for 24 hours a day and 365 days a year without any deviation in quality or degradation of system performance and all the parameter detailed in these specifications shall be guaranteed over the following environmental conditions:

- 2.1** Equipment Operating Temperature: 0 degree to + 40 degree Centigrade. Relative Humidity: 90% up to 35 deg centigrade. Storage Temperature: 0 to + 45 degree Centigrade

3. SITE ACCEPTANCE TEST (SAT) & COMMISSIONING

- 1.** It shall be the responsibility of the Contractor firm to submit the system test procedure for conducting the post-installation site acceptance testing. The procedure submitted by the Contractor firm shall be drafted in line with the standard practices followed in the industry and shall be in accordance with the test procedures. The acceptance test procedure on approval by AAI shall become the document for acceptance of the equipment after installation at the site.
- 2** The draft copy of system test procedure shall be made available to AAI before THIRTY calendar days of the schedule site acceptance date.
- 3** The Contractor shall supply, install, test and commission all hardware and software as per the requirement of the tender with the system. Contractor firm shall supply Technical documents (hard and soft copy - one set each) at site. The system shall be commissioned after successful completion of - SAT approval, operational & maintenance training and all the works under the scope of the tender.
- 4** After commissioning of the PA System, agency shall arrange tests from independent qualified PA system consultant for verifying/ measuring all the parameters of PA system as per design, DBR and specifications such as Real Time Analysis (RTA), speech intelligibility, uniformity of loudness, frequency response measurement etc. as per directions of EIC.

4. PATENTS, LIABILITY & COMPLIANCE OF REGULATIONS

- 1** Contractor firm shall protect and fully indemnify AAI from any claims for infringement of patents, copy right, trademark or the like.
- 2** Contractor firm shall also protect and fully indemnify AAI from any claims from Contractor firm's workmen/ employees, their heirs, dependents, representatives, etc. or from any other person(s) or bodies/ companies, etc. for any act of commission or omission while executing the order.
- 3** Contractor firm shall be responsible for compliance with all requirements under the laws and shall protect and indemnify AAI completely from any claims/penalties arising out of any infringements by Contractor firm or its workmen/employees.

12.2 PUBLIC ADDRESS & VOICE ALARM SYSTEM (PAVA)

- 1** A centralized Public Address & Voice Alarm System will be used to broadcast General Announcements - both manually and automatically to all areas of the facility and, Flight and Passenger Voice Announcements, and Background Music to Public Address Zones. The specified system shall be continuously supervised, monitored and automatically adjust the announcement signals sound level(s) relevant to the facility ambient noise. The specified system shall be integrated with the facility Telephone system enabling programmed facility DTMF (Dual tone multi frequency)/VOIP telephones to access and make emergency announcement through PAVA system, Automatic Flight Announcement System, Software & Integration of Flight Announcement System with Flight Information system will be a part of PAVA proposal. The system shall be network based and shall operate over standard Ethernet topology using common switch components for both audio and control signals. System field devices such as microphone stations, amplifier mainframes, Ambient noise collectors, logic I/O collectors and Monitor/Test collectors shall be Ethernet network based and shall connect to a dedicated VLAN of the house network through local Telecommunication (TC) rooms.

PAVA system is Design based, OEM need to refer Plan, Elevation, Sections, need to propose Audio Simulation along with the proposal, for Material Finish & NRC OEM/Contractor refer Arrival / Departure /Mezzanine Floor & Ceiling drawings.

1.1 LIFE SAFETY CODES, STANDARDS & REGULATIONS

The proposed PAVA system equipment shall be certified by Recognized test laboratories & comply with any of one in the following life safety & voice alarm codes & standards.

- a. EN 54-16: Voice alarm control and indicating equipment.
- b. EN 54-4: Power supply equipment.
- c. EN 54-24: Components of voice alarm systems – Passive Loudspeakers,
- d. ISO 7240-16 Sound systems for emergency purposes,
- e. BS 5839-8: 2013, Code of Practice for the design, Installation, Commissioning and maintenance of voice Alarm Systems.
- f. BS 6259: 1997, Code of practice for the design, planning, installation, testing and maintenance of sound systems.
- g. IEC 60268-16: 2011, Objective Rating of speech intelligibility by speech transmission index.
- h. ISO 7240-16:2007, Sound System Control & Indicating Equipment.
- i. ISO 7240-19, Design, Installation, Commissioning & Service of Sound system for Emergency purposes.

- j. PH120 as per clause 26.2 BS 5839-1 of Circuit Integrity PH120, Fire Survival armored Cable.
- k. IEC 60065: Audio, Video and Similar electronic apparatus – safety requirements.

1.2 ABBREVIATIONS

- AAS - Automated Announcement System
- CAN - Airport Communication Network
- AODB - Airport Operational Database
- AVC Automatic Volume Control
- BMS-Building Management System
- BSI - British Standards Institute
- CPU - Central Processing Unit
- dB – Decibel
- DSP - Digital Signal Processor
- EN - European Norm
- FACP - Fire Alarm Control Panel
- IEC - International Electro technical Commission
- IP -Internet Protocol
- ICD -Interface Control Document
- ISO- International Standardization Organization
- LAN -Local Area Network
- MTBF -Mean time between Failure
- MTTR- Mean time to Repair
- NFPA -National Fire Protection Association
- NTP -Network Time protocol
- PAVA- Public Address & Voice Alarm System
- SPL -Sound Pressure Level
- STI- Speech Transmission Index
- SNMP -Simple Network Management Protocol
- TCP/IP- Transmission Control Protocol/Internet Protocol
- TER - Telecommunication Equipment rooms
- UPS -Uninterrupted Power Supply
- V-LAN -Virtual Local Area Network
- VE -Voice Evacuation
- WAN -Wide Area Network
- AA -Automatic Announcement
- CA - Central Announcement

- DGA - Digital Gate Announcement
- DGAC - Digital Gate Announcement Client
- QS - Queue Server
- QC - Queue Client
- ASS - Announcement Synthesis System
- AST - Audio Streaming Server
- URL- Uniform Resource Locator
- GUI - Graphical User Interface
- IATA - International Air Transport Association
- PAX- Passengers

1.3 PERFORMANCE REQUIREMENTS

- 1.3.1.** The system shall be based on distributed architecture with IP Based DSP control units processing digital audio with routing & switching features at the telecom equipment rooms. The DSP control units located in telecom equipment room shall have integrated synchronization for Audio & Control data via the LAN network.
- 1.3.2.** There shall be no single point of failure as the system should have backup unit for amp and controller.
- 1.3.3.** The DSP Control unit must have high MTBF parameters with a minimum of 250,000 hours of MTBF specified for continuous & uninterrupted operation.
- 1.3.4.** Loudspeaker type & position shown on the drawing are indicative. The contractor shall be required to provide a 3D acoustic modelling & simulation in all the typical areas of the terminal building to determine the STI & SPL results expected for approval of Engineer In charge (E.I.C) during the detailed design stages. Each Loudspeaker type, location & mounting height shall be coordinated with Architectural and Interior Design Consultants.
- 1.3.5.** The Contractor shall be responsible to ensure that the proposed Loudspeaker type & location shall deliver the specified speech intelligibility index.
- 1.3.6.** The PAVA sub contractor shall provide 3D Acoustic Modelling & Simulation for the typical areas of the AAI for the preemptive prediction of Speech Transmission Index. The sub-contractor may utilize any one of the following software tools with latest available versions for the Acoustic Modelling & simulation works.
 - Ease - AFMG, Germany
 - Ulysses - IFB Soft, Germany
 - Catt-Acoustic - CATT, Sweden
 - Odeon - Bruel & Kjaer, Denmark

1.4 SCOPE OF WORK

- 1.4.1.** The contractor must employ a specialist voice alarm sub-contractor with adequate number of manufacturer certified engineers & technicians for the supply, installation, configuration, testing, commissioning & maintenance of an integrated high performance public address &

voice alarm(PAVA) system equipped with features for the broadcast of live announcements, prerecorded messages, emergency evacuation messages & automated flight announcements. The system shall be equipped to broadcast back ground music signals in certain areas of building as advised by the Engineer In change (E.I.C)/Airport Operation Manager. The system shall be designed & configured to deliver high performance digital audio with high speech intelligibility in all the areas of the Terminal Building.

1.4.2. The contractor scope of work is a turnkey solution with responsibility for fully provisioning for PA system including design, supply, installation, configuration and testing, commissioning, maintenance and defect liability for the following equipment:

- a) PA Speakers
- b) Acoustics Analysis from OEM/SI must provide the required details of their system.
- c) TCP/IP PA Controller with redundancy (1Main +1Redundant)
- d) TCP/IP Class D Multichannel Amplifiers (Min 250watt) with DSP with automatic single/multichannel channel backup switching
- e) TCP/IP Digital Microphone Paging system
- f) Server / Workstation based Automatic Flight Announcement
- g) Ambient Noise Analysis System with digital signal processing technique including Noise Sensing Microphone
- h) Background Music sources (BGM)
- i) Volume control for VIP,CIP /Lounges
- j) Circuit Integrity PH120, LPCB, Fire Survival Cable
- k) Public Address software integrate with Digital Automatic Announcement system
- l) 42U, 19" Rack with Cable manager, required no. of Trays, Fan, Wheel, gland plate, cable glands, ferrule, thimble, lugs, cable tie, cable /equipment dressing material complete as required.
- m) Server/workstation as required
- n) Public Address system should be so that it can integrate with Airport Common LAN network for distributed architecture
- o) UPS power supply
- p) Supply, Acoustic analysis, Installation, Integration, Testing, Commissioning, maintaining the system during DLP

1.5 INTERFACE OF PUBLIC ADDRESS SYSTEMS WITH FOLLOWING SYSTEMS/EQUIPMENT'S

- VOIP/DTMF Telephone System
- Automatic Announcement system
- Flight Information Display System or Automatic Flight Announcement System
- Fire Alarm System to ensure PA system sources (BGM and Flight Announcements) are muted in the event of an Emergency/ Fire Alarm trigger and that emergency messages are played in affected/ all zones.

1.6 SYSTEM ARCHITECTURE

- 1.6.1.** The basis of design of this system is a networked distributed scheme intended to provide maximum flexibility and high performance. Different system architectures may be proposed if it can be proven to provide same or better features, performance, operational effect of equipment failure, flexibility for future expansion. Contactor shall include all costs for differences in hardware, cabling, and conduits caused by different system architectures.

1.7 TERMINAL BUILDING PA SYSTEM

- 1.7.1.** The Terminal Building PA System for the announcements should be divided to multiple Zones, please refer Plans, Section, Elevation, Acoustic details & accordingly Propose the design based solution.

- 1.7.2.** The Terminal Building however should be divided initially in to Zones as given below but the system shall be scalable enough to accommodate additional zones by addition of amplifier's in future. The terminal building drawing including indicating the areas for providing PA system and Car parking drawing, indicating the area where car calling system has to be provided .

Zones

- a) Z1 Check-In - Domestic & Associated Escalators, Elevators & Toilets
- b) Z2 SHA Domestic & Associated Escalators, Elevators & Toilets
- c) Z3 Domestic Frisking area
- d) Z4 Departure Level Kerb area
- e) Z5 Offices, PBB, Common areas, Control Rooms, Common Toilets, OOG Rooms IT Rooms, Data rooms or any other area which are not part of common public & used for Terminal building Departure & arrival
- f) Z6 Domestic Arrival & Associated Escalators, Elevators & Toilets
- g) Z7 Domestic Departures BUS Lounge & Associated Escalators, Elevators & Toilets
- h) Z8 Air Side Kerb Area
- i) Z9 City Side Arrival Kerb area
- j) Z10 to 12 Spare zones with amplifier

- 1.7.3.** Please note that in the above Zones wherever the spaces have double or triple height and with width (throw distance for the loudspeaker) of the space is more than 20 Meters & the ceiling height is more than 6m, the beam steering Digital Line Arrays with DSP technology with inbuilt/separate Class D amplifiers must be used with Network Connectivity RS-485 (Full Duplex)/RJ45, optically isolated, general status (DSP running, signal present etc.), amplifier monitoring and load monitoring schemes, external pilot tone detection (20kHz - 28kHz, level \geq 22 dB), built-in ambient noise microphone, override through external ambient mic, frost protection, thermal overload protection. The 3D mapping of the proposed Digital Line Array by the vendor in the system integration should be possible, that is the software module file (.dll file) should be importable in the mapping software for the 3D mapping and computer simulation

and 6-dB SPL head room calculation must be done while selecting the speakers and amplifier power.

- 1.7.4.** In the above zones announcement could be made either individually or to all zones or a group of zones. Suitable marking should be provided in the announcement consoles for identifying the Zones. By selection, the user should be able to transmit announcement to particular Zone or zone groups in the terminal building
- 1.7.5.** The Terminal Building PA system should have system priority as under:
 - Fire announcement/ alarm: 1 No. with 1st priority
 - Airport Manager's office: 1 No. with 2nd priority
 - PA System Control Room: 1 No. with 3rd priority
 - Departure check-in area: 4th priority - only for local announcements
 - SHA & Departure gates: 5th priority - only for local announcements
 - Arrival Hall: 6th priority - only for local announcements
 - Car parking area: 1 Nos. with equal 7th priority - only for local announcements
- 1.7.6.** In addition to the above; the system shall be scalable for installation and upgradation of new zones and more announcing stations. The system should also have in-built provision of playing music & manual announcement and pre- recorded Announcements.
- 1.7.7.** Priority should be user programmable.
- 1.7.8.** The system should also be able to play different BGM (background music) in different zones. Normally music should be played through speaker network in all the selected Zones/ areas. However, the system should automatically override music of the relevant zone for announcements to be heard. The announcements should not interrupt BGM (Back Ground Music) in other zones than the ones being paged.
- 1.7.9.** The distribution network in the control room should receive the input signals from paging consoles/Stations and music input, and processes, then distribute it through speakers. Digital Signal Processing techniques should be used for equalization (RTA based) in the halls. Microphones meant for Noise sensing should be installed in various locations of the terminal to get noise level to regulate the volume in that area automatically and maintain signal to noise ratio about 10dB to 15dB while maintaining a minimum of 65dB and a maximum of 85dB SPL with + or - 3dB variation over 90% of each zone. The PA system shall allow modification of these parameters to set to desired levels as per site requirements. The system, in evacuation mode, should be able to override all settings and work in a preconfigured setting, including announcement level.
- 1.7.10.** The PA system shall have the ability to accurately differentiate between ambient noise and actual program material to vary the attenuation only based on ambient noise. In event of failure of noise analysis system, shall reset the paging levels in affected zone to pre-set levels. OEM must confirm on their Letter head / Data Sheets that proposed NSM (Noise sensing Microphone) are meant for the required purpose and not for Public Addressing purpose. For announcement purpose, microphones should be provided to ensure maximum isolation from the ambient noise so that the system delivers highly intelligible announcements and paging. In addition, the system should be capable to connect two or more NSM (Noise sensing Microphone) in one zone and should be monitor-able with the system logs.
- 1.7.11** AGC (Automatic gain Control) and AEC should be provided in all zones where NSM's

(Noise sensing Microphone) to be installed to maintain the sound level automatically in all the public announcement areas of the terminal of the terminal building. This should be programmable for day and night and should work automatically with Schedule or calendar logic once it programmed.

- 1.7.12.** DSP/Controller shall have separate logic Processing and Logic objects, which should be freely programmable to make any kind of logic circuits using digital logic components (gate, truth tables, counters & comparator).
- 1.7.13.** DSP shall have Speech sense feature to enhance the quality of announcement.
- 1.7.14.** The network control unit shall have extensive audio processing possibilities for audio inputs and audio outputs. 24 band parametric equalization, limiter, and gain can be adjusted with the configuration software.
- 1.7.15.** System shall be capable to handle +5V unloaded logic output voltage up to 6 connections to give visual LED indication for master paging operator for successful announcement notification
- 1.7.16.** Sufficient number of loudspeakers should be provided to ensure essentially uniform distribution of sound meeting +/- 3dB uniformity in more than 90% all the Passenger/ Visitor and staff areas as required. In offices, VIP room, CIP room, restaurant etc., cabinet speakers with volume control should be used. For car call system, fully weather-proof Speaker speakers should be used. The type of speakers and locations of speakers, however, should be as per the performance requirements and simulation done and submitted by the Contractors.
- 1.7.17.** In the equipment room, all speakers' cable should be terminated in the main junction box and should be clearly marked with cable ferrules.

1.8 DESIGN PARAMETERS AND FUNCTIONALITY REQUIREMENTS

- 1.8.1.** The system should be capable of delivering distortion free audio output and Intelligibility meeting the target criterion of measured STIPA of minimum 0.6 or more in more than 90% of all the public area zones where the announcements are made.
- 1.8.2.** The system should allow an undistorted speech reproduction of 75db (peak up to 85db) SPL at listening level. The system should also provide uniform coverage within +/-3dB across more than 90% the entire area of all public zones of the terminal for the octave band 125Hz to 8 KHz. However, the integrator shall tune the system and make use of equalizer, crossover and other available signal processing capabilities of system to optimize the system performance. The frequency response of the PA system DSP/ Controller and amplifiers should be 20HZ to 20 KHz (+/- 3 dB)
- 1.8.3.** All Data of the System Integration Criterion shall be verified by the AAI Engineer Incharge. The Contractors should use calibrated Acoustical measuring equipment to satisfy the system integration criterion to the AAI Engineer In- charge as given in the tender document. The AAI Engineer In-charge would do the technical assessment of the system integration and all Contractors should extend full cooperation to the AAI technical team. The system should be of programmable matrix type for sound system management and control having modular structure for future expansion and up gradation to increase the zones as may be required. PAVA system is Design based, so OEM/SI need to refer Plan, Elevation, Sections, need to propose Audio Simulation along with the proposal, for Material Finish & NRC OEM/Contractor refer Arrival/ Departure/ Mezzanine Floor & Ceiling drawings
- 1.8.4.** The offered system should support broadcasting and routing of the digital announcements by automatic announcement sub-system that is external to the PA system and should have

necessary provision for input as well as processing the announcements. The system should have appropriate no's potential free

Analogue and Digital signal inputs for external audio feed.

- 1.8.5.** The system architecture should be such that it allows for future expansion. The system should be modular for ease of maintenance.
- 1.8.6.** The system should be programmable to provide for selection to allow a certain type of announcement to be routed to a specific zone in the terminal (such as fire, emergency etc.). The system should support minimum two announcement consoles in the control room/studio and also multiple remote announcement stations as may be required.
- 1.8.7.** The system should have a provision for playing continuous soft background music round the clock in all public areas of the airport terminal with music level of 55-60 dB SPL max value should be maintained. For inviting attention of announcement a pleasing chime should precede every announcement. The tone of the chime should be programmable to be different for emergency announcements. The music should cut off during the announcements.
- 1.8.8.** The PA system should support the broadcasting and routing of the alarm/ speech generated by fire detection and alarm system (an independent system) with provision for connecting audio line for processing.
- 1.8.9.** Reverberation time of each zone in the terminal should be considered and the Electro acoustical adjustments should be carried out to achieve the target criterion of measured STIPA 0.6 or more in 90% of each zone in all the public area where the announcements are made.
- 1.8.10.** The system integration should take in to consideration the height of the ceiling at various places critical distance and directivity factor of the loudspeaker system.
- 1.8.11.** Utilization of the zones as per traffic and distribution of loudspeaker system respectively.
- 1.8.12.** Capacity of amplifiers and the distribution network requirement with maintaining 6dB head room minimum.
- 1.8.13.** Peak hour occupancy of the spaces in different areas.
- 1.8.14.** Provision to avoid echo during announcement a suitable feedback suppressor/AEC and audio processor should be used in the system integration as may be required depending on the analogue or digital interface.
- 1.8.15.** Amplifiers to give distortion-free announcements with minimum 6dB SPL headroom.
- 1.8.16.** Provision of pink and white noise and test tone generator for testing the system should be provided to calibrate the system as may be required.
- 1.8.17.** Monitoring facility through speaker for individual amplifier output should be provided in the PA Rack.
- 1.8.18.** Facility for switching ON and OFF of the music from equipment rack to be given.
- 1.8.19.** The control system should have total access matrix, completely programmable and expandable having several inputs and outputs, each input can be directed to one or more outputs according to the configuration and the priority levels defined.
- 1.8.20.** The control system is to be of modular structure which can be assembled as per functions desired and subsequently expanded for future requirements.
- 1.8.21.** The control system should be easily configurable and programmable through external PC.
- 1.8.22.** The system should have facility for selective call for different zones with provision of avoiding priority conflicts.
- 1.8.23.** Automatic pre-recorded announcement system shall be used for general announcement information in form of prerecorded messages in Hindi, English and local language. However,

there should be provision for manual announcement. For the manual announcement professional microphones mounted on the Announcement consoles should feed the distribution system controller. Each announcement console should be provided with zone selection button(s) that should be programmed to route the microphone inputs to one or several power amplifiers. These amplifiers in turn should feed the loudspeakers located in the geographical and/ or functional zones with background music or announcements. However, the local announcement consoles installed in the terminal building should be programmed to automatically route the announcements originating from these local announcement consoles to the corresponding local area only.

1.8.24. All the boarding gates and car calling system shall have 4 button digital paging, station, and Airport Manager's office and PA System Control Room shall have desktop type digital call station.

1.8.25. Controller and Audio Power amplifier shall be from same make/OEM.

Public Address and Voice Alarm System

2. Scope of Work

This specification defines a multi-function public address and voice alarm system which shall serve all PA Zones as shown on the PA Drawings. The primary purpose of the PAVA system is to deliver clear intelligible speech and voice alarms to areas as designated in the drawings. The system shall interface with other systems at the airport as detailed herein the contractor scope of work is a turnkey solution with responsibility for fully provisioning for PA system including design, supply, installation, configuration and testing, commissioning, maintenance and defect liability for the PAVA equipment.

- a) Scope of work shall include, but not limited to, supply, Installation, Testing & Commissioning of PAVA System Equipment e.g. Amplifiers, Matrix Controllers, Announcement Consoles, Loud Speakers, Line Array/Column Speakers, Unit Horns, Conduiting and Cabling etc. PA & Voice evacuation System shall cover all areas of newly Integrated Passenger Terminal Building, and outside parking areas.
- b) Scope of work shall also include integration of PAVA System with proposed Addressable Fire Detection & Alarm System being installed in the Airport Terminal Building.
- c) AFAS (Automatic Flight Announcement System) is proposed to be provided along with FIDS (Flight Information Display System) at new integrated Terminal Building. PA System will be integrated with AFAS for the purpose of automating Flight Announcements.
- d) Due to physical parameters of the building area, there will be resonance at certain frequencies resulting in boosting or absorption of sound level at these frequencies, which shall be totally undesired. In order to resolve this problem, inbuilt Parametric Equalizer in the Matrix Controller shall be adjusted to cut- off or boost these frequencies from announcement in the relevant area/zone of the building. This exercise will be done in all areas of the Terminal Building, in order to achieve maximum clarity of announcements.

- e) PAVA System shall play background music at low level in all announcement zones. In case of Flight Announcement/Fire Alarm/Paging announcement in a particular zone, Background music shall be muted in the relevant announcement zone and Announcement shall be made as programmed to provide enough SPL (Sound Pressure Level) levels to comply with the design criteria. Background Music in other zones shall not be affected in such scenario.
- f) The PAVA system for the proposed New Terminal Building should be integrated using an IP and Microprocessor based Audio processor with public address sound management system with an objective to allow announcement for the flight schedules & General Announcements from more than one location having facility to play music during idle time. All announcements should meet the target criterion of speech Intelligibility with presided by a pleasant chime.
- g) The contractor should integrate the system taking into consideration the acoustics of building, geometry of space & other technical specifications & functional requirements provided in the tender (e.g Mapping of Sound field converge, Speech Intelligibility, Speech Clarity and Direct Sound to Reverberation ratio). The tenderers should use computer Aided Simulation using 2D and 3D Mapping. Techniques to carry out Acoustics and Electro acoustics simulation and mapping of sound distribution. Detailed architectural drawings of the spaces shall be issued by the project Architect of the Airport building.
- h) The Contractor shall carry out acoustic modelling of the areas requiring PA, as defined in this specification and drawings and provision of all speakers, noise sensing microphones etc. as required to meet the specified performance requirements, regardless of the quantities and layout shown on the drawings.
- i) Driven by acoustical parameters of public areas, speakers and associated components will be designed to suit the new terminal building layouts.
- j) The contractor scope of work is a turnkey solution with responsibility for fully provisioning for PA system including design, supply, installation, configuration and testing, commissioning and defect liability for the PAVE equipment

After completion of work, but before final commissioning, the contractor through his associate specialized agency shall carry out measurement of sound parameters in various areas of the Terminal building as well as other areas covered by PA System this will be compared with the design parameters as indicated in these specifications. Any connected work, not indicated above, but considered necessary for satisfactory completion of work shall also be carried out within the Scope of this Work.

3. *Installation Standards*

Installation shall be carried out by technically well qualified and certified personnel as per the requirements.

4. *Integration*

- a) PAVA System is required to be integrated with Airport Flight Information Display System in order to have an effective **Automatic Flight Announcement System (AFAS)**.
- b) PAVA System shall also be integrated with Fire Alarm system (FAS) and other systems as per requirement by AAI.
- c) PAVA System shall need to be integrated with overall IT infrastructure per requirements provided by AAI.
- d) These technical specifications are to be used as guidelines for the contractor to offer similar or better audio equipment.

5. General Conditions

Specialized Agencies deployed by the contractor for the job shall be required to match the requisite criteria as per the tender.

- a) Specialized Agencies deployed by the contractor for the job is required to submit a letter/certificate from the OEM indicating that the tenderer/system provider is their authorized outlet, fully empowered to provide after sales service during the life span of equipment/item in concerned City/ Region. The OEM must have their own fullfledged service center in India for ensuring proper service support to client operational. Service registration in this regard must be submitted.
- b) The proposed PAVA Systems should be proven technology. The OEM of equipment must submit a confirmation that the products proposed are latest in production/development and is not discontinued / End of production. Suitable document to the satisfaction of EIC & Consultant Must be submitted for verification and approval before start of work.
- c) The PAVA systems components like controller, Amplifier, call station etc. must be EN54-16, certified by statutory body and an internationally recognized and authorized laboratory. Suitable document to the satisfaction of EIC & Consultant Must be submitted for verification and approval before start of work.
- d) The OEM must be experienced manufacturer with reference to successful working systems of PAVA systems. Suitable document to the satisfaction of EIC & Consultant Must be submitted for verification and approval before start of work.
- e) Specialized Agency associated for execution of the system, should either be a manufacturer of major component/s of the relevant System, or should have successfully executed such system, as a System Integrator, at Airports. & Should have been authorized and fully supported by Manufacturer/s for execution of work & its warranted support AAI reserves the right to disallow the working agencies whose performance at ongoing project(s) is below par and usually poor or has been issued letter of restrain/ temporary or permanent debarment/ blacklisting by Airports Authority of India (AAI) / Ministry of Civil Aviation (MoCA) / Dept. of Expenditure (DoE), Ministry of Finance.

6. PAVA System ' Overall design requirements/guidelines

The contractor shall carryout 3D and 2D mapping of all the PA zones given in this tender. As such, the following simulation printouts need to be submitted to demonstrate the P.A. System

Integration:

- a) The contractor shall construct a 3D model (using acoustics and electro acoustics simulation software) of the areas for all the Zones under investigation and apply acoustical material on to the walls, ceiling and floor as per the schedule of finishes.
- b) The public audience area must be defined in the 3D model to evaluate the proposed P.A. system by the contractor.
- c) The proposed Loudspeakers by the contractor to be placed precisely in the 3D model at X, Y and Z coordinates to achieve the desired target criteria. The firing angle of the loudspeaker systems must be adjusted for the public audience area to achieve the desired results.
- d) The system design shall take into consideration - the height of the ceiling at various places, critical distance and directivity factor of the loudspeaker system. Loudspeaker Technical data such as sound pressure level, power rating, frequency response, sound field coverage to be submitted. All equipment technical data sheet along with the original catalogues to be submitted.

7. **Audio Performance Criteria**

(a) The PA system shall achieve a minimum Speech Intelligibility of:

7.1 *Area Speech Intelligibility*

- i. Inside the terminal building except departure area - 0.5 or better RASTI for 95% of each PA zone
 - ii. Departure - 0.5 or better RASTI for 90% of each PA zone
 - iii. Outside the terminal building 0.3 or better RASTI for 90% of each PA Zone
- (b) All areas will need to have uniformity of coverage. This implies that the system shall be designed to deliver average speech sound levels of 3db or better for 90% of the area within distortion limits and will not exceed 85db for normal paging announcements for relevant areas in line with the Area Speech Intelligibility, as outlined below
- | | |
|---------------------------|------|
| Quiet and Worship Areas - | 65dB |
| Back of House area - | 75dB |
| Restrooms - | 70dB |
| Arrivals and Concourses - | 75dB |
- (c) In an open public space, the system shall deliver 15dB above average ambient sound level or 5dB above the maximum sound level, whichever is lesser.
 - (d) In a closed space, the system shall deliver 10dB above average ambient sound level or 5dB above maximum sound level, whichever is lesser.
 - (e) The system should allow an undistorted speech reproduction of 85db (peak up to 97db) SPL at listening level for all public areas and 75 dB (peak upto 97 dB) SPL at listening level for all non-public areas. The system should also provide uniform coverage within +/-3dB for the entire area

of the terminal for the octave band 250Hz to 8 KHz. The frequency response of the PA system should be 125 HZ to 12.5K Hz +/-1dB for Terminal Building.

- (f) To meet Speech Intelligibility and other target sound parameters, Reverberation Time/ RT60 of 2.0 to 3 Second may be considered. In case, where RT60, as per calculations of the contractor, works out to exceed this value, EPC contractor will provide suitable Sound Absorbent material in relevant areas of the Terminal Building/ provide acoustical Ceiling with absorption coefficients, as given in the schedule of finishes of civil works to correct RT60 value and achieve desired speech intelligibility. Use of Acoustical ceiling will ensure fine-tuning the sound characteristics of terminal building, potentially saving time and money on expensive remedial treatments that may otherwise become necessary following project completion.

7.2 Preparation of Spectrogram and its analysis of parameters

- a) Spectrogram of Direct SPL at 85dB at listening plane (1.2 M above floor level) at frequency band from 250 Hz to 4 KHz. The sound field coverage should be uniform for the complete audience area within +3dB.
- b) Spectrogram of Direct SPL at 85dB with split time of 7 ms (L7) at listening plane (1.2 M ht.) at frequency band from 250 Hz to Three Octave. The sound field coverage should be uniform for the complete audience area within +3dB.
- c) Spectrogram of Total SPL at frequency band from 250 Hz to 4 KHz.
- d) Spectrogram of Sound Field Overlap of Speakers at frequency band from 250 Hz to 4KHz.
- e) Spectrogram of D/R (direct field and reverb field) Ratio at frequency band from 250Hz to 4KHz.
- f) Spectrogram of RaSTI (Rapid Speech Transmission Index) meeting target criteria as described in the 'Audio Performance Criteria' where the announcements are made with ambient noise level at 60dB at frequency band from 500 Hz to Third Octave.
- g) Spectrogram of Critical Distance Analysis at frequency band from 250 Hz to 4 KHz.
- h) Spectrogram of D/R ratio with split time of 7ms at frequency band from 250 Hz to 4KHz the sound field coverage should be more than -15 dB for complete audience area.
- i) Spectrogram of Speech Intelligibility at split time 50ms at frequency band from 250Hz to 4KHz and the speech clarity should be - 1.0 dB (-1.0dB) or above.
- j) Spectrogram of Articulation Loss Analysis for frequency band from 500Hz to Third Octave should not be more than 7%.
- k) Spectrogram of Articulation Index should be 0.90 or above.
- m) All Mapping to be carried out at simulated noise level of 60 dB.

- n) The PA system should be integrated so that it delivers all frequencies in the range of 300Hz to 18 KHz + 1 dB or better. Computer Simulation printouts for Frequency Response curve at listener location in all the Zones must be submitted.
- o) Design shall ensure that there are no echoes in the Arrival hall, Departure Hall, concourse, customs, immigration & others areas.

7.3 Functional & Performance Requirements

- a) A multi-function IP based Public Address and Voice Alarm (PAVA) system, Dante/Omneo/OCA/Ravenna/or equivalent enabled, IS/AES 67 and IS/AES 70 compliant provided shall be a state-of the- art digital networked system and shall be scalable.
- b) The IP based PAVA System Dante/Omneo/OCA/Ravenna/or equivalent enabled, AES 67 and AES 70 compliant shall be certified to International standards of Emergency Sound System EN 54 (IEC 60849) certified with following features as a minimum and as required to make the system complete and operational in all respects as per specifications, drawings, and standards as required. The systems shall have open interface for interfacing other services such as Fire alarm system, FIDS and Building Integrated service software.
- c) The IP based PAVA system Dante/Omneo/OCA/Ravenna/or equivalent enabled, AES 67 and AES 70 compliant shall enable all day to day live announcements and pre-recorded audible information along with emergency pre-recorded and live announcements triggered by the Fire Detection/Alarm system.
- d) The system shall provide an audible, manageable voice announcement system that will support the fire strategy for the building through provision of automated voice alarm instructions and support the operational processes of the building by enabling public address announcements.
- e) The system hardware shall be digital including microphone page stations and associated queuing, telephone interfaces if required, distribution of announcements, to single, multiple or any combination of zones (zone descriptions are provided in the drawings), background music, recorded announcements, pre-recorded and assembled messages.
- f) To achieve Life safety critical objectives the PAVA system shall be required to perform to the highest achievable standards on a continuous basis (i.e. 24/7). All life safety critical parts of PAVA system should be fully monitored, from Microphone Paging Stations to each PA speaker zones to ensure that any faults are dealt quickly and efficiently.
- g) The complete IP based PAVA system Dante/Omneo/OCA/ Ravenna/or equivalent enabled, AES 67 and IS/AES 70 compliant shall be comprised of strategically distributed subsystems, connected via the LAN, that when integrated together, form a complete system for announcement and message management.

- h) The system shall include FIDS integration feature. The system architecture should be modular for expansion in future and ease of maintenance.
- i) All system components shall be digitally monitored, including and not limited to, Messages, Amplifiers, and back up amplifiers, Speaker Circuits, Network Controllers, Paging Microphone, UPS and the 230 VAC line. Each amplifier/ line circuit shall be monitored individually and shall report any faults back to the Controller as well as the paging microphone.
- j) Each amplifier shall not be loaded more than 80% of its rated capacity and all the public area zoning - every alternate speakers shall be connected with two (2) different amplifiers circuits.
- k) The offered distribution controller should be equipped with an audio switching and routing matrix as required. Each of these outputs should be further distributed to several power amplifiers that drive the loudspeakers located in the public address zones corresponding to each output. The internal wiring of the offered distribution system controller should be made installer friendly and should have provision of inter connections and termination of various units and sub-units.
- l) AGC (automatic gain control) circuit should also form part of the distribution system controller and should have independent automatic volume control channels. In environments such as an airport, the background noise level fluctuates constantly therefore the AGC is must.
- m) The system shall be capable of sending messages automatically to any zone at anytime interval, without affecting the music in the other areas.
- n) The System shall be able to be programmed to provide any Cause & Effect programs after integrating with the Fire Alarm System/FIDS, thus Alert/Evacuate messages can be programmed and delayed as well as played on any zone / floor as per the Cause &Effect approved by the Consulting Engineer/AAI.
- o) The system shall be capable of being used for everyday background music and public announcement duties with the fire alarm initiated emergency announcements overriding all other facilities.
- p) The voice alarm system shall be capable of broadcasting pre-recorded emergency alarm messages and live speech in the event of fire. In case of paging announcement from Fire Control Room for any particular Zone/s, PA System announcement shall be bypassed/ overridden in the relevant PA Zone
- q) The systems shall be capable of broadcasting 30 or more pre-recorded messages and different live calls simultaneously to different or group of zones as per the total number of zones as per design/ DBR.
- r) Evacuate signal relates to a general evacuation message and alert message corresponds to standby instructions.

- s) In addition, a Fire Drill, Bomb Alert, Earth quake alert and an All clear message shall be incorporated into the operation. A fire alarm broadcast signal shall cancel any public address operation and shall override it.
- t) Provision to avoid echo during announcement a suitable feedback suppressor and audio processor should be used in the system integration as may be required depending on the analogue or digital interface.
- u) Paging any zone shall not interrupt music in other zones.
- v) Facility for switching ON and OFF of the music from equipment rack shall be provided.
- w) The Terminal Building PA System shall be divided in to different PA Zones as per design.
- x) In the zones announcement could be made either individually or to all zones or simultaneously.
- y) Suitable marking should be provided in the announcement consoles for identifying the Zones. By selection, the user should be able to transmit announcement to particular Zone in the terminal building.
- z) The control system should have total access matrix, completely programmable and expandable having several inputs and outputs, each input can be directed to one or more outputs according to the configuration and the priority levels defined.
- aa) The control system should be easily configurable and programmable using front panel controls or through external PC.
- bb) In addition to the above: the system should have provision for installation and upgrading new zones and more announcing stations. The system should also have in-built provision of playing music & manual announcement and pre-recorded Announcements.
- cc) The system should also be able to play different BGM (Back Ground Music) indifferent zones. Normally music should be played through speaker network in all the selected Zones/ areas. However, the system should automatically override music of the relevant zone for announcements to be heard.
- dd) The announcements should not interrupt BGM in other zones than the ones being paged. The system, in evacuation mode, should be able to override all settings and work in a preconfigured setting, including announcement level.
- ee) For announcement purpose microphones should be provided to ensure maximum isolation from the ambient noise so that the system delivers highly intelligible announcements and paging.

- ff) Automatic pre-recorded announcement system shall be used for general announcement information in form of pre-recorded (preferably by single person) messages in Hindi, English and local language. However, there should be provision for manual announcement. For the manual announcement professional microphones mounted on the announcement consoles should feed the distribution system controller.
- gg) Each announcement console should be provided with zone selection that should be programmed to route the microphone inputs to one or several power amplifiers. These amplifiers in turn should feed the loudspeakers located in the geographical and/ or functional zones with background music or announcements. However, the local announcement consoles installed in the terminal building should be programmed to automatically route the announcements originating from these local announcement consoles to the corresponding local area only.
- hh) The level of PA announcement shall be uniform at listening level of an adult person (1.2 M ht. from the floor). For the STI requirements, refer the audio performance criteria section.
- (ii) Reverberation time of each zone in the terminal should be measured and the Electro acoustical adjustments should be carried out to achieve the target criterion specified the relevant section.
- ij) All Data of the System Integration Criterion shall be verified by the AAI Engineer Incharge.
- kk) The contractor should use calibrated Acoustical measuring equipment to satisfy the system integration criterion to the AAI Engineer In-charge as given in the tender document. The AAI Engineer In-charge would do the technical assessment of the system integration and all contractor should extend full cooperation to the AAI technical team.
- ll) The system should be of programmable matrix type for sound system management and control having modular structure for future expansion and up gradation to increase the zones as may be required.
- mm) The offered system should support broadcasting and routing of the digital announcements by automatic announcement sub-system that is external to the PA system and should have necessary provision for input as well as processing the announcements. The system should have appropriate potential free /Analogue and Digital signal inputs for external audio feed.
- nn) The system should support a priority mechanism with various priority levels for different announcements. The system should have provision for automatically controlling the volume of announcements in a given area depending upon the ambient noise level in that area.
- oo) Suitable noise sensing microphone should be installed in Public zones to sense the ambient noise level prior to the announcement.

- pp) Volume regulation should be automatic for delivering the output of respective power amplifier depending on the noise sensing microphone input and maintaining signal to noise ratio 16dB to 20dB. The noise sensing system should continuously adjust level to maintain the S/N ratio as specified above.
- qq) The system should have a provision for playing continuous soft background music round the clock in all public areas of the airport terminal with music level of 55-60dB max value should be maintained. For inviting attention of announcement, a pleasing chime should precede every announcement. The tone of the chime should be programmable to be different for emergency announcements.
- rr) The PA system should support the broadcasting and routing of the alarm/ speech generated by fire detection and alarm system (an independent system) with provision for connecting audio line or Potential free contact interface for processing.
- ss) INTEGRATION WITH BMS: The PAVE system shall be interfaced with the BMS system for Centralised Alarm & Messaging via BMS work station at the control room. The interface shall be based on a seamless IP protocol such as SNMP via the Network or any building automation controls such as Bacnet or Modbus or Opc.

The PAVE System shall have OPC Interface Modules for integration with BMS System but Programming shall be done by concerned BMS system contractor. The following Alarm functions shall be made available as a minimum requirement:

- Power fail alarm
- Amplifier fail alarm
- Fault alarm of digital call station
- Fault alarm of loudspeaker circuit
- Network Fail Alarm

7.4 General Requirement of the Public Address and Voice Alarm System

- a) The system shall be fully IP-network based.
- b) All system devices such as system controller, amplifiers and call stations shall communicate via IP, using an Audio over IP (AoIP) protocol that supports IS/AES67 for audio and using AES70 for control, with encryption and authentication to prevent unauthorized access, misuse and modification of data.
- c) The audio part shall support Layer 3 connections via routers between subnets with latency of less than 10ms and synchronized outputs.
- d) The control data part shall be guaranteed by Transmission Control Protocol (TCP) Layer 4.
- e) The system shall support >100 simultaneous channels for music routing and making calls, with encryption and authentication to protect against eavesdropping and hacking, using an uncompressed, high-definition digital audio format with 24-bit sample size and 48 kHz sample rate.

- f) A system based on a single system controller shall support at least 120 system devices and minimum 20 zones.
- g) System functionality shall be defined in software, allowing for regular updates for functional and/or security improvements.
- h) The system software shall run on the system controller with additional firmware on other system devices for device-related functions. Upload and installation of new firmware into the system devices shall be secure.
- i) System configuration shall be possible using a standard web browser, connected to the embedded webserver in the system controller, using HTTPS (HTTP Secure) communication. It shall support multiple access levels with associated access rights or it can be based on redundant PC based software with adequate redundant hardware.
- j) After completion of the system configuration, no connection to a PC shall be required for operation.
- k) The system software shall support the discovery and assignment of all system devices in a system and the individual configuration of each device.
- l) The system software shall support configurable call definitions for user calls and related actions that can be assigned to virtual and/or real control inputs and call station buttons.
- m) A call definition shall define the following: priority, start and end tones with volume setting, an audio input for live speech insertion with volume setting, a message or sequence of messages with a number of repetitions and volume setting, maximum call duration and optional automatic scheduling with duration and interval.
- n) The system software shall permit uploading of individual wav-files for messages and tones to the system controller, with integrity supervision of stored wav-files. It shall support zone definition and zone grouping with amplifier channel to zone assignment. The system software shall configure and control all device inputs and outputs in the system, including audio processing functions, operation modes, assigned functions and connections and the supervision thereof.
- o) The system shall include diagnosis and logging software, supporting different modes of enquiry, including call events and fault events. It shall be possible to view fault events, collected by the system controller, on a call station screen, including the fault status of connected third party equipment. It shall be possible to acknowledge and reset faults and alarm states, and to log these actions.
- p) The system devices shall be certified for EN 54, marked for CE and be compliant with the RoHS directive.
- q) Warranty shall be two years minimum.

8. PAVA System Components:

PA system shall comprise of the following.

- a) programmable PAVA Controller
- b) PAVA Amplifier
- c) Microphone with Zone Selection or local Announcement
- d) Speakers
- e) Noise sensing microphones
- f) MP3 Player for playing multiple channel of Music
- g) Rack housing for the control system and Amplifiers etc

- h) Distribution network /Conduits & cables
- i) Associated equipment, if any, required for SITC of PA System

8.1 System Controller

- a) The system controller shall dynamically assign network audio channels for audio routing between system devices across multiple subnets.
- b) It shall support >100 simultaneous High-Definition audio channels (24-bit, 48 kHz) for music routing and making calls, with encryption and authentication to protect against eavesdropping and hacking.
- c) The controller shall be configured in N+N hot stand by configuration with 100% speaker circuits operational even in the standby mode for automatic failover and work either in standalone mode or with a PC connected to it.
- d) It shall be capable of receiving Dante/Omneo/OCA/Ravenna enabled and AES67 audio streams.
- e) The system controller shall provide an interface for control data and multi-channel digital audio over IP using an integrated 5-port Ethernet switch for redundant network connections, supporting RSTP and loop-through cabling.
- f) The system controller shall have dual power supply inputs and power supplies.
- g) The system controller shall manage all devices in the system to provide the configured system functions.
- h) It shall incorporate a supervised storage for message and tone files with networked playback of up to eight streams simultaneously.
- i) It shall keep an internal log of fault events and call events.
- j) The system controller shall provide a secure TCP/IP open interface for remote control and diagnostics.
- k) The system controller shall provide front-panel LED indications for the status of power supplies and the presence of faults in the system and provide additional software monitoring and fault reporting features.
- l) The system controller shall be rack mountable.
- m) The system controller shall be certified for EN 54-16, marked for CE and be compliant with the RoHS directive.
- n) Warranty shall be two years minimum.

8.2 Four or more-multi channel Amplifier

- a) The 4 or more -channel amplifier shall be DSP enabled Class D and fully and natively IPnetworked based, not requiring external converters capable of receiving Dante/ Omneo/ OCA/ Ravenna/ or equivalent enable and AES67 audio streams.
- b) The amplifier shall adapt the maximum output power of each amplifier channel to its connected loudspeaker load, with free assignable output power per channel for a total maximum of 500 watt or more per amplifier as per design requirement, supporting 70V or 100V operation with direct drive capability and outputs that are galvanically insulated from ground.
- c) Every amplifier shall have an independent spare channel for redundancy or one separate spare amplifier for providing channel wise redundancy for a cluster of N main amplifiers, where $N \leq 7$. The switching of the amplifiers from main to stand by mode shall be a hot redundancy with 100% speaker circuits operational even in the stand by mode for automatic failover.

- d) The amplifier shall provide an interface for control data and multi-channel digital audio over IP using single/dual Ethernet ports for redundant network connection, supporting RSTP and loop-through cabling, with automatic failover to an analog lifeline input.
- e) The amplifier shall have dual power supply inputs and power supplies.
- f) All amplifier channels shall have independent A/B zone outputs with support for classA loudspeaker loops.
- g) All amplifier channels shall supervise the integrity of connected loudspeaker lines without interruption of audio distribution.
- h) The amplifier shall provide front-panel LED status indications for the network link, ground fault, power supplies and audio channels, and provide additional software monitoring and fault reporting features.
- i) The amplifier shall be rack mountable (1U) and feature software-configurable signal processing including level control, parametric equalization, limiting and delay for each channel.
- j) The amplifier shall be certified for EN 54-16, marked for CE and be compliant with the RoHS directive.
- k) Warranty shall be two years minimum.

8.3 *End-of-Line Device*

- a) The end-of-line device shall only require a connection with the end of the loudspeaker line to supervise its integrity.
- b) Supervision reliability shall not depend on the number of connected loudspeakers.
- c) Supervision shall be inaudible and not interrupt audio content.
- d) The end-of-line device shall be certified for EN 54-16, marked for CE and be compliant with the RoHS directive.
- e) Warranty shall be two years minimum.

8.4 *Multi function Power Supply*

- a) The multifunction power supply shall contain four independent mains power supplies with power factor correction and dual output connection facilities to power up to three 600 W amplifiers and to power a system controller and two call stations.
- b) The multifunction power supply shall have an integrated battery charger for a connected battery, and independent converters to use the battery as a backup power source for all connected loads in case of mains failures.
- c) Failover to the backup battery shall be without interruption of output power.
- d) It shall use a single 12 V VRLA backup battery to eliminate the need for battery balancing, while maximizing battery lifetime and power density.
- e) The multifunction power supply shall have eight general purpose control inputs with connection supervision and eight voltage free control outputs.
- f) The multifunction power supply shall provide an interface for control data and to receive a backup audio channel over IP using an integrated 6-port Ethernet switch for redundant network connections, supporting RSTP and loop-through cabling.
- g) Two ports shall have PoE to provide redundant power to a call station.
- h) The backup audio channel shall be available as analog lifeline to connected amplifiers.

- i) The multifunction power supply shall provide front-panel LED indications for status of the power supply sections, mains and battery, network link and fault presence, and provide additional software monitoring and fault reporting features.
- j) The multifunction power supply shall be rack mountable (2U). The multifunction power supply shall be certified for EN 54-4, marked for CE and be compliant with the RoHS directive.
- k) Warranty shall be two years minimum.

8.5 Desktop Call Station

- a) The desktop call station shall provide an interface for control data and multi-channel digital audio over IP using dual Ethernet ports for redundant network connection, supporting RSTP and loop-through cabling. The audio over IP should comply AES 67 standard for audio and AES 70 for control with optional encryption and authentication to prevent unauthorized access, misuse and modification of data.
 - b) It shall receive Power over Ethernet (PoE) via either one or both network connections.
 - c) The desktop call station shall provide a backlit full-color capacitive touch panel LCD as user interface for business and evacuation purposes.
 - d) The desktop call station shall accept up to four optional extensions, each offering 12 configurable buttons for zone selection and other purposes.
 - e) It shall provide control and routing of live speech calls, stored messages and music with volume control per zone.
 - f) The desktop call station shall have a gooseneck cardioid microphone for live calls and a 3.5 mm jack line level input for background music.
 - g) It shall provide software-configurable signal processing including sensitivity control, parametric equalization and limiting.
 - h) System should have provision of adding new Announcement Zones and additional Announcement Stations/Consoles, as per requirement
 - i) The desktop call station shall be certified for EN 54-16, marked for CE and be compliant with the RoHS directive.
 - j) All Announcement Stations/Consoles of PAVA shall be connected to Controller using CAT 6/STP CAT 6 cable.
- Warranty shall be two years minimum.

8.6 Wall mount Call Station

- a) The wall mount call station shall provide an interface for control data and multi-channel digital audio over IP using dual Ethernet ports for redundant network connection, supporting RSTP and loop-through cabling.
- b) It shall receive Power over Ethernet (PoE) via either one or both network connections.
- c) The wall mount call station shall provide a backlit full-color capacitive touch panel LCD as user interface for business and evacuation purposes.
- d) The wall mount call station shall accept up to four optional call station extensions, each offering 12 configurable buttons for zone selection and other purposes.
- e) It shall provide control and routing of live speech calls, stored messages and music with volume control per zone.

- f) The wall mount call station shall have a hand-held omnidirectional microphone for live calls and a 3.5 mm jack line level input for background music
- g) It shall provide software-configurable signal processing.
- h) The wall mount call station shall be certified for EN 54-16, marked for CE and be compliant with the RoHS directive.
- i) Warranty shall be two years minimum.

8.7 Call Station Extension

- a) The call station extension shall offer electrical and mechanical connection facilities for use with a desktop or wall mount call station.
- b) It shall provide 12 configurable buttons for zone selection and other purposes.
- c) Each button has tactile feedback and a light ring activation indicator, complemented with a set of multi-color LEDs for function related status indications.
- d) The call station extension shall have a removable front cover to put language independent button labels behind the front cover.
- e) The call station extension shall be certified for EN 54-16, marked for CE and be compliant with the RoHS directive.
- f) Warranty shall be two years minimum.

8.8 Music Player

All music transmitted from music Player will be routed through the Central Equipment rack to the zone /zones selected. Music player shall have minimum configuration with 2 USB port and Sound card support the latest MP3/MP4/WMA/AV1/WMV etc. format for playing music.

8.9 Loudspeakers

The system shall have various loudspeaker types for individual areas, as per the requirement to achieve the best possible audio performance. The type of speakers and locations of speakers, however, should be as per the performance requirements and simulation done and submitted by the EPC Contractors. All passive loudspeakers shall have multi-tap constant voltage transformers. The loudspeakers finish shall match that of the interior for better aesthetics. The system shall use passive and/or active steerable line array column loudspeakers for acoustically challenging areas such as check-in hall, security check and hold areas, arrival hall etc.

i) 6W Ceiling mount speaker

S. No.	Specification	Requirement
1	Type	Flush-mount Metal Ceiling speaker
2	Fire dome	Yes
3	Rated Power	6W
4	Maximum power	9W
5	Power tapings	6/3/1.5W
6	Rated Voltage	70/100V

7	Sound Pressure Level (SPL)	98dB @ 6W (1 kHz at 1m) or better
8	Opening Angle 1 KHz / 4 KHz (-6 dB)	150/50 or better
9	Frequency Range	190Hz to 18KHz or better
10	Certification	IS/EN54-24

ii) 6W Wall mount speaker

S. No.	Specification	Requirement
1	Type	Wall mount Metal grille speaker
3	Rated Power	6W
5	Power tapplings	6/3/1.5/0.75W
6	Rated Voltage	70/100V
7	Sound Pressure Level (SPL)	98-102dB @ 6W (1 kHz at 1m) or better
8	Opening Angle 1 KHz / 4 KHz (-6 dB)	horizontal 140° or better , vertical 140° or better
9	Frequency Range	300Hz-15kHz or better
10	Certification	IS/EN54-24, IS/UL 94-V0

iii) 60W Line array speaker

Sl. No.	Specification	Requirement
1	Type	Line array loudspeaker
2	Maximum power	90/ 100W
3	Power tapplings	60/30/15W
4	Rated Voltage	70/100V
5	Sound Pressure Level (SPL)	108dB or better 110 @ 60W (1 kHz at 1m)
6	Opening Angle 1 KHz / 4 KHz (-6 dB)	horizontal 210° / 132° vertical 50°/ 20°
7	Frequency Range	100 Hz to 15KHz or better
8	Certification	IS/EN54-24

iv) 60W Cabinet speaker

Sl. No.	Specification	Requirement
1	Type	Two-way surface mount speaker
3	Input transformer	60W

5	Power tappings	60/30/15/7.5W
6	Rated Voltage	70/100V
7	Sound Pressure Level (SPL)	108dB or better
8	Nominal impedance	8Ω
9	Frequency Range	60Hz to 17 KHz or better
10	Bracket	80° rotation
11	IP Rating	IP55 or better
12	Certification	IS/EN54-24, UL 94

v) Active Line Array Speaker

Active line array with built in DSP, DSP 32bit floating point, 900 Mflops ADC/ DAC 24bits S-D, 128 x oversampling ADC-DAC, network interface, with software configurable vertical coverage, with ambience noise sensing microphone, thermal overload protection, with RJ-45, ethernet 100 Mbps interface, 24bit word length.

Sl. No.	Specification	Requirement
1	Type	Active Line array
3	Sampling Rate	48kHz
5	Maximum throw	20 m, 30m and 50m depending on the length of the array
6	Dynamic range	>105 dB
7	Sound Pressure Level (SPL)	90 dB SPL or better
8	Opening angle at 1 kHz/ 4 kHz (-6 dB): horizontal vertical	130° Software Configurable
9	Frequency Range	130 Hz to 17kHz (±3 dB) or better
11	Network Interface	RS 485 full duplex
12	Compliance	IS/EN60065

vi) Horn Speaker

Sl. No.	Specification	Requirement
1	Type	Horn Speaker
3	Input transformer	10W
5	Power tappings	10 / 5 / 2.5 / 1.25 W
6	Rated Voltage	70/100V

7	Sound Pressure Level (SPL)	110dB or better
8	Opening angle at 1 kHz / 4 kHz (-6 dB): horizontal vertical	120°/35 120°/35
9	Frequency Range	300Hz-5kHz or better
11	IP Rating	IP65
12	Certification	IS/EN54-24, UL 94

Alternate models of loudspeakers may be proposed if it can be proven to provide same or better features, performance as per site conditions.

8.10 Speaker cable

- Speaker Cable (In Conduit) 2 C x 2.5 sq.mm fire survival cable (600/1000V) with class-2 Copper conductor having halogen free ceramified silicon insulation as per BS EN 50363 and low smoke zero halogen (LSZH) inner & outer sheath. Should comply to EN 610342 & EN 60754-1. The cable should meet fire performance circuit integrity test as per BS EN 50200:PH-120 & BS 6387 CWZ. Outer sheath should be in red colour with Antirodent & LSZH properties including end terminators.
- Speaker Cable (without Conduit) 2 C x 2.5 sq.mm fire survival armored cable (600/1000V) with class-2 Copper conductor having halogen free ceramified silicon insulation as per BS EN 50363 and low smoke zero halogen (LSZH) inner & outer sheath. Should comply to EN 61034-2 & EN 60754-1. The cable should meet fire performance circuit integrity test as per BS EN 50200:PH-120 & BS 6387 CWZ. Outer sheath should be in red colour with LSZH properties including end terminators.
- Microphone Cable (In Conduit)
“Supply & commissioning of 3c x 1.5 sq.mm Fire Survival Circuit Integrity unarmoured screened cable of 300/500V rated, twisted with Class-2 annealed copper conductor having crosslinkable ceramified Silicon insulation as per BS EN 50363 along with ATC drain wire, aluminium tape screening and LSZH outer sheath. Should comply to EN 61034-2 & EN 60754-1. Should meet fire performance circuit integrity test as per BS EN 50200 & BS 6387 CWZ (950 Deg. C for 3 hrs). Outer sheath should be in red colour and have LSZH properties.

8.11 Control Workstation

The control workstation shall be used to control, program and Monitor the complete Digital Public address. Using the control software, it should be possible to program audio routing, amplifier level, music level, Call station microphone level, Chime tones, pre-recorded message, alarm inputs, define zone, priority level etc.

It shall also be possible to view all systems operational and alarm/fault events log. The software should show log all announcement details with time, zone etc., amplifier failure, automatic

amplifier standby status, amplifier overload/short-circuit/ground short, main failure, system restart, call station error/disconnection etc.

Sl.No.	Specification	Requirement
1	CPU	Intel Core i7 or better
2	Memory	8GB RAM or higher
3	HDD	500 GB HDD or higher.
4	Power supply	Hot Swappable redundant power supply.
5	NIC	Dual Integrated 10/100/1000 Mbps ports
6	Sound	Sound card & Speakers
7	Antivirus	Licensed Antivirus with update subscription valid till warranty and AICMC period.

8.12 Software and Management

The PA system shall be a software driven system with business rules engines. The control work station shall be provided with access control. The system shall be accessible via the provided application or through web-browser interface. The software shall be able to create new business rules or modify the existing ones, it shall be able to create/modify zone groups for paging stations. The software shall help define the priority levels, manage schedule of announcements etc.

8.13 Noise Sensing Microphones

- (a) High quality Noise sensing microphones with necessary cabling as required should be installed in various Public PA zones. These noise sensing microphones shall be Omni directional microphones with a support construction including mounting rod and junction box suitable for mounting on the flush/ceiling/wall to the approval of architect.
- (b) The noise sensing microphones should sense the ambient noise level in the area in which they are installed. The average of this noise level at an instant just before the announcement is broadcast, should be sampled by the automatic gain control (AGC) circuit for adjusting the output of its associated power amplifier in such a manner that the audio output from the corresponding power amplifier during the announcement is held at 16dB to 20dB above the ambient noise level in that area as may be required.

8.14 Equipment Rack

These shall be standard 19 inch racks used for electronic equipment. The Rack is consisting of: -
Provision for housing:

- Sub rack for housing additional amplifiers
- Monitor sub racks
- Cooling Fans

- Head set for monitoring
- If required Main/std. by 24VDC sub-rack
- Mains panel with racks
- Required interconnectivity
- All the control equipment and the power amplifiers shall be mounted in these standard 19" racks. The racks shall be located not less than 750 mm clear from the wall of the equipment room. If two or more racks are required, the racks shall be mounted side by side and bolted together.

Items of the same function shall be grouped together, either vertically or side by side. All operational controls except the mains on-off switches shall be symmetrically arranged at a convenient height of not lower than 750 mm nor higher than 1700 mm from the floor.

8.15 SS /GI Pole

SS pole shall be supplied inside terminal building wherever required & GI Pole shall be supplied outside area as per design requirement.

8.16 TESTS TO BE CARRIED OUT BY Contractor

The successful contractor shall carry out several tests to determine the quality and the performance of the installed sound system. These tests should be carried out in all the indoor passenger circulation zones of the building using professional measuring test equipment. All the necessary test equipment required for measuring the various acoustic and electroacoustic parameters should be arranged by the tenderer and shall not be provided by Airport Authority. A computerized test report showing the measured values for the various acoustic parameters in all the zones should be submitted by the tenderer, failing which the work would not be treated as complete. The Contractor shall submit the measurement tool calibration certificate before the testing to the AAI and measurement tool should comply the IEC/BS standards. The different tests should be performed by the tenderer to ascertain the audio quality, intelligibility, function and performance of the system should be as under.

Sound Pressure Level (SPL) of all zones in different areas.

- i) Intelligibility Tests of all zones in different areas.
- ii) Reverberation Time of all zones in different areas.
- iii) RTA of octave band 125Hz to 8 KHz at +/- 3 dB
- iv) Any other relevant test as may be required by AAI for assessment of the PA system and its performance of all zones in different areas.

Note: All the tests should be measured in the presence of the AAI Engineer Incharge and should be carried out to the satisfaction of AAI Engineer In-charge. If necessary AAI team may ask some additional STIPA through STI & RTI measuring instrument, to be carried out to evaluate the performance of the audio system installation. All the above measurements shall be verified by the Airport Authority of India by their own equipment or third party measurements shall be performed for verification of acoustical consultant from contractor side.

8.17 GUIDELINE FOR REVERBERATION TIME MEASUREMENT: STI

The tenderers are required to measure the RT60 (reverberation time) of all the Zones and submit the following:

- a) Name, Model Number, calibration certificate & accuracy of the equipment's used to measure the RT60 should be submitted in tender.
- b) Measurement report of the RT-60 measurement to be submitted to the Engineer in charge.
- c) The Reverberation Time (RT-60) to be measured at the following frequencies.
 - I. 125Hz -
 - II. 250Hz -
 - III. 500Hz -
 - IV. 1 KHz -
 - V. 2 KHz -
 - VI. 4 KHz -
 - VII. 8 KHz -

8.18 GUIDELINE FOR STI MEASUREMENT:

Measured data of the STIPA of all the Zones at 6 (Six) locations in each Zone to be submitted to AAI as and when the halls are ready.

- a) STIPA at Listener location 1 -
- b) STIPA at Listener location 2 -
- c) STIPA at Listener location 3 -
- d) STIPA at Listener location 4 -
- e) STIPA at Listener location 5 -
- f) STIPA at Listener location 6 -

8.19 GUIDELINE FOR RTA MEASUREMENT:

Frequency Response curve at Six-listener zone to be measured & submitted.

8.20 GUIDELINE FOR SPL MEASUREMENT:

Total SPL shall be measured for all the passenger zone and submitted to AAI (Six location per Zone), SPL result should meet the System Design requirement.

8.21 SUBMITTALS

i. 3D mapping of the Zones as specified below shall be approved before starting the work to AAI/PMC. The name of the software used for this simulation should be clearly mentioned in the documents submitted by the bidder.

- Check In Hall
- Domestic Departure
- Domestic Baggage Handling Area

ii. Contractor shall have to achieve following parameters in 3D simulations

- STI should be 0.6 or better in 90% of the area
- Direct SPL @ 1KHZ and 3150 HZ should be 85dB or better with +/- 3dB in 90% of the area

- Total SPL @ 1KHZ and 3150 HZ should be 85dB or better with +/- 3dB in 90% of the area
 - SPL @ 250 to Broadband should be 85dB or better with +/- 3dB in 90% of the area
 - 50dB Noise should be considered for the simulations
- iv. After successful completion of the computer simulation as per the parameter given below in this document, the contractor shall pack the project and submit the packed project file (in a CD) created on the simulation software. The contractor shall use commercially available software to do his 3D computer simulation. The packed project file should be importable in to the other commercially available software to evaluate and scrutinize by AAI/PMC.
 - v. Schedule of Finishes usually the Materials used in construction of Terminal Building are shall be provided by AAI/PMC.
 - vi. Product data sheets
 - vii. Layout plans with loudspeakers placement, NSM (Noise sensing Microphone) and paging stations location
 - viii. Block Schematics with redundancy and zone details
 - ix. Rack equipments layouts.
 - x. Electrical load details with heat dissipation.
 - xi. FIRE alarm interface document

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WATER SUPPLY PUMPS, WATER TREATMENT PLANT, DRINKING WATER FOUNTAINS AND WATER COOLERS

13.1 TECHNICAL SPECIFICATIONS FOR WATER SUPPLY PUMPS, WATER TREATMENT SYSTEM, DRINKING WATER FOUNTAINS AND WATER COOLERS

SCOPE OF WORK

The scope of work in this subhead shall consist of furnishing all labour, materials, equipment and appliances necessary and required to completely do all work relating to the design supply, installation, testing & commissioning of water pumping, water treatment system and drinking water fountains as described hereinafter.

The work shall include the following: -

Design, Supply, installation, testing & commissioning of

- a) Water supply pumps, Submersible Borewell pumps, Hydro-pneumatic pumping system for Domestic, flushing Water Supply
- b) Water filtration system and Water Softening Plant with all accessories.
- c) Drainage pumps for disposal from pump room, tunnel and basement.
- d) Controllers & Indication Systems for Tanks & Pumps
- e) Drinking water fountains and Water coolers with (RO+UV).
- f) Motor control panels, power and control cabling and allied electrical works.
- g) Pipes, valves, accessories, hangers, supports, delivery and suction header and connection to proposed pipe work.
- h) Painting of equipment and piping.
- i) Supply of spare pump for borewell.

1 DESIGNS, DRAWINGS AND TECHNICAL SUBMITTAL

a) AFTER AWARD OF THE WORK:

On the basis of GFC drawing issued by EPC contractor with soft copy, the Contractor shall submit 03 (Three) sets of shop drawings for pumps & water treatment equipment. Pump & water equipment selection for the entire installations to be provided under this contract along with supporting calculations, charts etc, and proposed general arrangement of equipment's for water supply pump & water treatment equipment within 30 (Thirty) days for approval of AAI before proceeding with the work. The contractor shall also furnish all clarifications and explanations as may be desired by AAI promptly for early finalization of the design.

The work to be executed as per approved shop drawings & technical submittal/specifications.

b) ON COMPLETION OF WORK:

The contractor shall submit 4 (Four) sets of O & M manuals for pumps & water treatment system including MCC panels, circuit diagram, manufacturers technical catalogues, detailed specifications of items provided along with softcopy of As-built drawings and copies of Test Certificates of all major equipment duly bound in neat and presentable booklet forms within 30 days of completion of the work.

1.1 COORDINATION

The Contractor shall be required to co-ordinate his activities with all other agencies executing Air Conditioning, Electrical, firefighting, Civil and other works at site.

1.2 CIVIL WORKS

All associated civil works are included in Contractor's scope of work unless otherwise specified. Civil works like excavation for pipe laying underground with pedestal supports or chase cutting in the wall/ceiling or making hole in the RCC floor/ceiling or in brick wall for piping, grouting etc. including making good the same after completion, small size pedestals or any other minor civil works required in connection with the installation of the system are included in the scope of work of this contract.

Foundation for pumps, panels and other installations as required in pump room is also in the scope of contractor. The rates quoted by the agency shall be inclusive of all the above scope of work. Hence nothing extra shall be paid on this account.

2 WATER SUPPLY PUMPS (Filter Feed Pumps)

2.1 Water supply pumps shall be suitable for clean water. Pumps shall be multistage, Inline vertical, centrifugal pumps with SS casing, stainless steel impeller, stainless steel shaft of 316 grade, CI base with CED coating and directly coupled with TEFC induction motor of class "F" insulation & efficiency class minimum IE-4 of suitable capacity & RPM, IP 55 enclosure, suitable for operation on 415 volts $\pm 10\%$, 3 phase, 50 Hz, A.C. supply. Each pump should operate at a specific duty point of max Efficiency.

2.2 Pump and motor shall be mounted on a common M.S. structural frame as required as per site conditions.

2.3 Each pumping set shall be provided with 150 mm dia. gunmetal "Burden" type pressure gauge with gunmetal isolation cock and connecting piping.

- 2.4** Provide vibration-eliminating pads appropriate for each pump.
- 2.5** Provide expansion bellows on suction and Discharge side of the Pump and wherever required.
- 2.6** Provide rate of flow measuring meter with bypass arrangement with every set of pumps required and submit to Engineer in Charge for approval before execution.
- 2.7** All water supply pumps shall be provided with mechanical seals.

13.2 HYDRO-PNEUMATIC SYSTEMS (Domestic, Flushing directly to fixtures /water point)

Hydro pneumatic systems (With Variable Frequency Drive for Domestic water supply, Flushing water supply)

- 3.1** The scope of this section covers compact packaged type skid mounted, self-contained variable frequency drive hydro pneumatic systems, one hydropneumatic Set (2w+1S) working + one hydropneumatic Set (2w+1S) as standby or as per design based on site requirement and approved by AAI. The skid mounted, factory assembled hydro- pneumatic system shall be provided with pressure transmitters, frequency convertor for noiseless operation of the pump at varying duty point. The convertor shall be provided with short circuit safety, earthing, over current, under voltage protection. The pump shall be complete with suction and delivery pipe. The system shall comprise of multiple pumps working and one stand-by to meet the system discharge requirements.
- 3.2** It shall conform to the following specifications:
- (a) Pumps shall be vertical, multistage centrifugal and fulfills all specifications as specified in the Clear water pump section.
 - (b) Pressure vessel shall be of non-corrosive FRP composite construction lined with NSF and /or FDA listed material, like high density polyethylene with fully replaceable polyurethane with air cell burst pressure of minimum of five times the vessel operating pressure with charging connections to discharge pipe line with necessary flanges, gaskets, isolating valve, nuts/ bolts etc. with suitable foundation bolts & other accessories, complete. Capacity provided shall be as per manufacture specifications.
 - (c) Panel mounted microprocessor multi pump controller with large graphical display and variable frequency drive (VFD with each pump) with pressure sensor transmitter. The graphical display is capable to show number of pumps running & also communicate with other controllers following with open protocol through RS485 port. System should be capable to compensate for frictional losses at lower flows. All alarms should be displayed in the controller. The panel should also have provision for manual / automatic alternate (cyclic) operation of pumps, ON/OFF switch, dry run protection, inter connecting power and control cabling etc. complete.

3.3 CONTROL PANEL (FOR HYDRO-PNEUMATIC SYSTEMS)

The control panel shall be compatible with BMS system and terminals for:

- Remote monitoring.
- Pump fault.
- Analog output signal for frequency convertor
- Pressure sensor / Pressure switches as per system requirement.

3.4 GENERAL

The hydro pneumatic system shall be capable of maintaining a constant pressure at varied consumption. The hydro pneumatic system shall be complete with pressure sensor and microprocessor based controller for flow control by means of frequency variation (in case of VFD operated system). The controller should have time control switch to adapt pump operation to actual requirement in peak load situation. The control panel should also have manual operation.

The pumping system shall perform the following functions:

- Shut off the pump at zero demand.
- Shut off the pump at zero suction (Dry Run protection)
- Protect the pump from overvoltage, under voltage, overload & earth fault.
- Vary the time of pump speed acceleration and deceleration
- Compensate for higher friction losses at high flow rates.
- Send out a signal for remote monitoring of flow as well as pressure.
- Conduct automatic test run of pumps at set time.
- Keep track of run time for pumps.
- Perform run time equalization of all pumps in system.

3.5 INSTALLATION

Hydro pneumatic systems shall be mounted on a common base frame & installed as per manufacturer's recommendations. Pump sets shall be mounted on machinery isolation cork or any other equivalent vibration isolation fitting. The vibration isolation pads, foundation bolts etc. shall be supplied by the Contractor. Contractor shall ensure that the foundation bolts are correctly embedded.

Pump-sets shall be factory aligned, wherever necessary, site alignment shall be done by competent persons. The entire system along with pumps & control panel must be sourced from single manufacturer only for unit responsibility.

3.6 TESTING OF PUMPS

The pumps shall be tested according to the standard recommendations of the manufacturer. The following parameters are to be recorded and plotted and submitted to AAI.

- a. Discharge Q
- b. Pressure P or Head H

- c. Motor voltage and current.
- d. Efficiency

The power consumption is to be computed and cross checked with manufacturer's data. Any abnormalities, if noted, shall be brought to the notice of the manufacturer and necessary corrective action be taken before commissioning and handing over, without any extra cost. Manufacturers test certificates shall also be submitted to AAI for verification.

3 SUMP PUMPS FOR PUMP ROOM/ Tunnel

4.1 Sump pump grinder type set shall be compact, submersible type with class "F" insulation of suitable capacity & RPM operating on 415volt \pm 10%, 3 phase, 50Hz AC supply, with non-clog free flow open CI impellers, CI casing (Pump & Motor) with lifting assembly and having solid handling capacity of required size as per system requirement for lifting domestic sewage or muddy water/drainage.

4.2 Pump shall inclusive of all necessary accessories like valves; piping, Control Panel and Cabling, Level Controllers, Test and/or air vent cocks, etc. as required within the quoted cost. The Contractor has to ensure for smooth and trouble free operation after the commissioning of the entire system. Nothing shall be paid extra on this account. Below are the functions of panel.

- (1) All the working and standby pumps shall start/stop automatically and alternatively.
- (2) Each pump shall start/stop automatically at pre-set levels and work alternatively in cyclic operation.
- (3) In case of pump getting overloaded, indication shall come on the panel and hooter will give sound non-operation of pump. In case of emergency due to high volume flow of incoming sewer or storm water all sewerage/storm water pumps shall start operating simultaneously.

4.3 PIPES & JOINTING

Heavy class-C G.I. pipes conforming to IS:3589 cut to required lengths including all necessary fittings (conforming to IS:1879) and specials such as bends, tees, unions, reducers, flanges & plugs etc. fixing at by clamps, hangers etc., (to be galvanized after fabrication) making fire sealant complete. Including two coats of Synthetic enamel paint of approved shade on pipes and supports as per pipe color code over a coat of primer.

4.4 LEVEL SWITCH IN WATER TANKS

The Contractor shall supply and install controller in the water tanks as indicated below and shown on the drawings.

Raw Water Tanks with some necessary requirement given below:

High level alarm (over-flow) Low level alarm;

Low level cut-out for raw water pumps. Earthing probe.

Treated Water Tanks in basement with some necessary requirement given below:

High level alarm (over-flow). Low level alarm.

Low water level cut-out domestic water pumps. Earthing probe.

Each probe shall be of the correct length for the particular application and tank location. Electrodes shall be of polished stainless steel 20 mm OD. Electrode holders shall be weather proof in all respect

The earthing probes shall be connected and wired to the building earth systems of the building

The level switch set shall operate with a stepped down voltage at 24V maximum. Stepped down transformers shall be provided for each set of control probes and shall be installed inside centralized control cubicles inside pump room.

4.5 PUMP INDICATOR

The following audible and visible indication shall be provided at the pump local control panels as applicable.

- a. Red "overflow level" indicator with buzzer for the associated water tanks.
- b. Amber "extra high water level" indicator for the associated water tank.
- c. Amber "high water level" indicator.
- d. Amber "low water level" indicator.
- e. Red "pump trip" indicator for each pump.
- f. Green "pump on" indicator for each pump.
- g. "Pump electrical supply healthy" indicator for each pump.
- h. Amber "remote/local" status indicator.

13.3 WATER TREATMENT SYSTEM

1 WATER FILTER

Vertical M.S. Dual Media filter (2nos filter–1multigrade filter, 2 activated carbon filter) fabricated from 6mm thick M.S plate shell and 8mm thick M.S. plate dished ends with 3mmnon-toxic, non-leaching rubber lining (rubber lining to be tested for pin-holes by spark tester) inside complete with initial charge of filter media, face piping (GI pipe class- C), diaphragm /butterfly/non-return valves, accessories, painting complete. Filter diameter calculation will submit the EPC contractor before execution.

2 UNDER DRAIN SYSTEM

Each filter shall be provided with an efficient under drain system comprising of collecting pipes, polypropylene nozzle's of manufacturer design. The entire under drain system shall be supported on M.S. plate or cement concrete supports provided by the contractor.

3 FACE PIPING

Each filter shall be provided within interconnecting face piping comprising of inlet, outlet and back wash complete with valves. Pipes shall be galvanized steel tubes to IS:1239 (Heavy Class). Fittings shall be malleable GI fittings as per IS: 1239.

4 Brine tank

Sodium Hypochloride dosing system consisting of one HDPE tank of suitable capacity with a positive displacement diaphragm dosing pump having variable flow rate of 0-8 LPH. The motor shall be suitable for operation at 240 V / single phase /50 Hz. Supply. The pump shall be supplied complete with necessary polypropylene piping, valves, strainers, low-level switch and injection fittings. The pump shall be speed & stroke control.

5 UV Protection

Ultraviolet dis-infection unit for tertiary treated water (with flow rating 0-8 LPS) with bypass arrangement. The dis-infection chamber shall be constructed of SS 316L on all wetted parts. The UV lamp shall be of low-pressure mercury vapour type with hard glass enclosure, the sockets shall be water tight & vibration resistant. The lamp life shall be rated for 9000 hours. The access to the UV lamp shall be without the need to interrupt the ballast circuit.

6 ACCESSORIES

- i) Air release valve with connecting piping.
- ii) 100 mm dia. dial bourden type gun metal pressure gauges with gun metal isolation, cock and connecting piping on inlet and outlet, causing shall be with cast aluminium stored enamel black finish cases.
- iii) Sampling cocks on low water inlet and filtered water outlet.
- iv) Connection with valve for air scouring.

Each filter shall be provided with clean and washed filter media of type and depths as recommended by the manufacturer.

7 BACK WASH

Backwash flow rate shall be suitable gallons/hr./sq.ft which shall be achieved by reversal of flow from water supply pumps through the pressure filter. Backwash shall be done once in 48 hours subject to the recommendations of manufacturer.

8 FLOW MEASUREMENT

The contractor shall provide one bye-pass type Rota meter reading LPH on delivery line of filter. The contractor shall supply one complete set of test kit for water treatment system.

9 WATER QUALITY

The domestic water treatment basis of design shall be as per raw water analysis. Contractor shall get the raw water analysis done at his own expense (in accordance to IS:10500 prior to submission of the water treatment scheme. No additional cost is payable in case of any variation in scheme due to water test results.

The contractor shall ensure domestic water of potable water standard after the treatment system shall be as per IS: 10500.

10 VALVES & ACCESSORIES

- 10.1** Valves 150 mm dia. above (inside screw and non-raising screw type) shall be sluice valve cast Iron body and Gunmetal seat with double flanged ends and valve wheel and shall conform to type PN 1.6 of IS: 14846.
- 10.2** Valves 80 mm dia. and above shall be cast iron butterfly valves suitable for waterworks and conforming to IS: 13095. All valves shall be suitable to

withstand the pressure in the system and rating shall be PN 1.6. All valves shall be right handed.

The direction of opening and closing shall be marked and an open / shut indicator fitted.

The Valve shall be fitted between two flanges on either side of pipe flanges. The Valve edge rubber shall be projected outside such that they are wedged within the pipe flanges to prevent leakages.

- 10.3** Valves 50 mm dia and below shall be made from forged brass ball valve and tested to 20 Kg/ cm² pressure. The valve shall be internally threaded to receive pipe connections.

The Ball shall be made from brass and machined to perfect round shape and subsequently chrome plated. The seat of the valve body bonnet gasket and gland packing shall be of Teflon.

The handle shall be of chrome plated steel with PVC jacket. The handle shall also indicate the direction of 'open' and 'closed' situations. The gap between the ball and the Teflon packing shall be sealed to prevent water seeping up to 14 Kg / cm² pressure.

The handle shall also be provided with a lug to keep the movement of the ball valve within 90 degree.

- 10.4** Non return valves 80 mm dia. and above shall be of cast Iron body and Stainless Steel seat. They shall conform to IS: 5312 and have companion flanges. They shall be Dual Plate Type suitable for both horizontal and vertical installation. A narrow mark in the direction of flow shall be marked on the body of the valve.
- 10.5** Non-return valve 50mm and below shall be gunmetal swing check valve confirming to IS: 778 Class- 2 tested to 24.5 Kg/cm².

10.6 STRAINER

Strainers shall be preferably of the approved type with fabricated steel bodies designed to the test pressure of 16 Kg/cm². Strainers shall be fabricated by minimum 1.2 mm thick stainless steel sheet with 3 mm dia. perforation holes. Strainers shall be provided with flanges or threaded sockets as required. They shall be designed so as to enable blowing out accumulated dirt and facilitate removal and replacement of screen without disconnection of the main pipe.

10.7 PRESSURE GAUGES

Pressure gauges shall be of 150mm dia. dial and of appropriate range and be complete with shut off valve etc. duly calibrated before installation. Care shall be taken to protect pressure gauges during pressure testing.

10.8 FLEXIBLE CONNECTION FOR PUMPS

10.9 All suction and delivery lines shall be provided with double flanged reinforced neoprene flexible pipe connectors. Connectors should be suitable for a working pressure of each pump. Length of the connector shall be as per manufacturer's details.

10.10 JOINTING

Pipes and fittings shall be jointed with screwed/flanged joints; flanges either screwed or welded complete and flanged joints with 3mm thick rubber gasket as per requirements complete with nuts, bolts and washers etc.

Fittings shall be of malleable iron galvanized of pressure ratings suitable for the piping system. Fitting for G.I. pipes shall include couplings, bends, tees, reducers, nipples, unions, bushes.

11 PIPING INSTALLATION

12.1 The Contractor on the award of the work shall prepare detailed working drawings showing sizes and locations of pipes and valves and air valves etc. Detailed plan and sections of the pump room equipment shall be submitted by the contractor.

12.2 Piping shall be properly supported on or suspended from stands, clamps, hangers etc., as specified and as required. The contractor shall adequately design all the brackets, saddles, clamps, hangers etc. and be responsible for their structural integrity. Shop Drawings of all proposed supports to be submitted for approval before execution of work.

12.3 Pipe supports shall be of steel, adjustable for height and primer coated with rust preventive paint and finish coated black. Where pipe and clamp are of dissimilar material, a gasket shall be provided in between. Spacing of pipe supports on main headers shall not exceed 3.0 meters in any case, and additional supports shall be provided on all bends, tees, and valves etc. as per requirements.

Pipe supports in pump house shall be floor mounted and of mild steel /

GI spacing of pipe supports shall not be more than that specified below: -

Nominal Pipe Size (mm)	Spacing (m.)
20 and 25	2.00
32 to 125	2.50
150 and above	3.00

Extra supports shall be provided at the bends and at heavy fittings like valves to avoid undue stress, on the pipes

12 TESTING

12.1 PUMPS

Contractor shall submit the performance curves of the pumps supplied by them. They shall also check the capacity and total head requirements of each pump to match his own piping and equipment layout. On completion of the entire installation, pumps shall be tested, wherever possible, for their discharge, head, flow rate, B.H.P. Where it is not possible at least the discharge, head and B.H.P. (as measured on the input side) shall be field tested. Test results shall correspond to the performance curves.

12.2 PIPING

All pipes, fittings and valves shall be tested by hydrostatic pressure of min. 1.5 times, the working pressure and subject to minimum of 10 kg/cm² in any case and with the consent of AAI.

Pressure shall be maintained for a period of at least two hours without appreciable drop in the pressure after fixing at site. A test register shall be maintained and all entries shall be signed and dated by Contractor(s) and AAI.

12.3 PAINTING

After the piping has been installed, tested and run for at least ten days. The piping shall be given two finish coats of approved color. The direction of flow of fluid in the pipes shall be visibly marked in white arrows or as directed by the AAI.

13 MOTOR CONTROL SYSTEM

EPC shall design WTP panel as per actual ratings and submit to Engineer In Charge for approval before fabrication, also provide logic controls. For switchgear, rating / panel specification please refer electrical specification.

The main switchboard shall be floor mounted, free standing, cubical type,

compartmentalized and shall be factory built fabricated by one of the approved switch board manufacturer. The board shall be fabricated from 2mm thick CRCA sheet and powder coated after seven tank process. The board shall be fabricated with IP 54 degree of protection suitable for operation of 415 volt $\pm 10\%$, 3 phase, 4 wire, 50Hz, AC supply. The switch board shall have provision for termination of cables from top as well as bottom with suitable knockouts. The layout shall be designed for convenient connections and inter-connections with various switchgears. Connections from individual compartments to cable alleys shall be such as not to shut down healthy circuits in the event of maintenance work becoming necessary on a defective circuit. A base channel of 75mm \times 5mm thick shall be provided at the bottom. A maximum of 200mm space between the floor and bottom most panel of unit shall be provided. The bus bar shall be of aluminium complete with heat shrinkable PVC sleeves. The fabrication of switch board shall be taken up only after the drawings for the fabrication of the same are approved by the AAI.

Control panel shall contain starters and safety protection for all pump controls etc. It shall also house the switchgears for incoming as well for outgoing supply. Provision of voltmeter (for incomer) & ammeter for incomer as well as for measuring the current drawn by each motor with selector switch, a set of LED indicating light for incoming phases as well as status indication of each equipment. The voltmeter & LED indication lamps shall be protected by MCBs.

All the motors shall be provided with fully automatic Star Delta/DOL starters with motor duty MCCBs for short circuit protection only (ICS = 100% ICU) & Overload Relays with contactors of suitable range & ratings for overload protection. Single phase preventers shall be provided for all 3 phase motors. Single phase preventer shall be in conformity with relevant ISI standards. Single phase preventers shall act when failure of one or more phases. Single phase preventer shall be voltage operated and of approved make.

The MCCB for incomer shall be with Thermal magnetic release & should provide adjustable setting for overload and short circuit protection with ICS = 100% ICU.

Interlocking shall be provided between switch and the door in such a way that the door of the panel cannot be opened when the supply is ON.

The panel shall be provided with all identification tags, danger board etc. as per standard. All control panels shall be provided with detailed control circuit diagram indicating the terminal numbers and color coding of the wires used in the panels. This diagram shall be pasted on the inner side of the cover and protected with PVC transparent lamination.

For detailed specification of switchgears & accessories, specifications under electrical sub head of contract shall be considered.

All pump control panels shall be compatible with BMS system.

14 POWER CABLING

Contractor shall provide all power /control cables from the motor control centre to various motors, level controllers and other control devices. All power cables shall be aluminum conductor XLPE insulated armored and PVC sheathed and control cables of copper conductor PVC insulated armored and PVC sheathed. All Power / Control cables shall have FRLS outer Sheath and stranded conductors of 1100 Volt grade. The cables shall be in drums as far as possible and bear manufacturer's name.

Specification of cable laying shall be followed as described in Internal EI package of this tender.

15 CABLE TRAYS

16 Specification of cable trays shall be followed as described in internal electrical package of this tender.

17 EARTHING

Main Electrical power up to the Electrical panel(s) in water supply Pump Room along with earthing shall also be considered in the scope.

All three phase motors / equipment shall be earthed with two independent earth conductors as per the requirement of Indian Electricity Rules and Regulation - 1956.

Earthing specifications shall be followed as described in Internal EI package of this tender.

13.4 SPECIFICATIONS FOR DRINKING WATER FOUNTAINS (RO +UV)

Supply installation, testing and commissioning of recessed bi level drinking water fountain, with double bubbler, bottle filling station, Drinking water fountain with minimum 50LPH RO+UV System, 50LPH cooling capacity, 50Ltrs Storage capacity, mechanical operation to activate the water flow of water. Stainless steel body Brushed Finish, SS bubbler guard operated between 50 to120 PSI, chilling unit suitable for R134a refrigerant, adjustable thermostat, with electrical protection rating. supply complete with all accessories.

NOTE : Complete system which will installed by the firm shall be compatible with Hydro Pneumatic water supply System to meet the operational requirement.



Specification for Water cooler with Inbuilt RO+UV

Storage type water cooler inbuilt 50 LPH RO+UV system with UV Lamp, minimum 5 stage purification, minimum 50 Ltr Cooling Capacity and 100 Ltr Storage Capacity with SS 304 grade outer and inner body.

SECURTIY EQUIPMENTS

10.0 TECHNICAL SPECIFICATIONS OF SECURITY EQUIPMENTS

1.0 INTRODUCTION

This section covers the detailed technical specification boom barriers at entry points of approach road and entry gate of the operational area along with motorized sliding gates at entry point of Operational area to enhance the safety & security of Airport and control of traffic at Airport.

The items which are not included in these technical specifications, same shall be executed in accordance with the latest relevant Indian/ international standards, sound engineering practices and the direction of Engineer-In-Charge.

It is to be noted that the all items covered under the scope of works to be installed at Airport and the contractor is responsible to maintain the aesthetics and bound to accept the airport security norms.

SCOPE OF WORK: The scope of works covers mainly the DSITC boom barriers at entry points of approach road and entry gate of the operational area also motorized sliding gates at entry point of Operational area as per BCAS and CPWD specifications.

Works including but not limited to the following are covered in the scope of work.

- i. Preparation of layout/drawing for boom barriers along with related electrical and communication cabling.
- ii. Design, supply, installation, testing and commissioning motorized sliding gate at entry point of operational area.
- iii. Cutting and excavation of road.
- iv. Supply, laying, testing and commissioning of power cables and their end termination.
- v. Supply, laying, testing and commissioning of related electrical, controls and communication cabling with other software & hardware.
- vi. Earthing of the system.
- vii. Site testing and other incidental job for successful commissioning of system.
- viii. Training AAI Engineers.

2.0 SPECIFICATIONS

2.1 GENERAL

In general the work shall be carried out as per BCAS guidelines and CPWD general specifications for External Electrical work (1994) amended up to date and specifications of OEM.

1. The offered equipment by the bidder shall be compact, fully solid state, highly reliable and shall use latest state of the art technology.
2. The design and selection of the offered equipment by the bidder shall be consistent with the requirements of long-term trouble-free operation with highest degree of reliability and maintainability.
3. All offered equipment by the bidder shall be manufactured to continuously operate safely without undue heating, vibration, wear, corrosion, electromagnetic interference or any similar problems.

4. The offered equipment by the bidder shall be designed for continuous operation (24-hours a day and 365-days a year). The design life of the equipment shall be a minimum of SIX YEARS.
5. This life shall be achievable through normal and regular maintenance.
6. All types of spares and spare modules of the offered equipment shall be readily available with the bidder during life-time of the equipment, for maintenance, repairs and up keep of the equipment during warranty, if applicable.
7. Offered equipment by the bidder shall undertake and ensure implementation of its offered solution and shall keep in view the safety and protection of personnel, during normal operation and maintenance or during malfunctioning of any equipment or its sub-component. This shall be ensured as an integrated feature of design, manufacture and installation of offered equipment by bidder.
8. Offered equipment by the bidder shall ensure adequate protection to be included for ensuring safety of personnel from any possible hazards, including EMI radiation, high voltages, etc.
9. The offered equipment by the bidder shall furnish the details of EMI and Safety Standards met by his equipment and built-in safety features.
10. The offered equipment shall be constructed on a modular basis, using plug-in type units and components to the extent possible. Parts subject to failure, wear, corrosion or other deteriorations or requiring occasional inspection, adjustment or replacement shall be made accessible and capable of convenient inspection and removal.
11. Input and output termination cables in offered equipment shall be properly labelled to permit ready identification of the incoming/outgoing wiring.
12. All interconnecting cables in offered equipment shall also be appropriately labelled to facilitate convenient interconnection and minimize chances of incorrect connection.
13. All connecting cables required to inter-connect the equipment shall be supplied by the bidder as a part of the offered system. All cables shall be fully assembled, connector pre-terminated and factory tested at the time of supply as part of overall system check.

2.2 Licenses

All Hardware system/component and Software supplied by bidder shall be licensed, as applicable, in favour of Airports Authority of India and valid for lifetime of the offered system.

2.3 Mains Power Supply

- a. Complete offered equipment shall operate with an un-interrupted AC power 230 Volts ($\pm 10\%$) single phase 50 Hz $\pm 5\%$. Reliable over & under voltage and over current protection circuits shall be provided in the power supply units of offered solution. The power supply units in complete offered solution shall be self-protecting, and shall protect connected equipment against conducted interference, noise, voltage dips and surges & impulses.
- b. Mains Power Supplies used in offered solution/equipment shall be rugged enough to withstand variation in mains voltage and frequency over a long period of time so that the failures in the equipment due to power supply are minimized.

2.4 Installation Standards.

- a. Installation shall be carried out by technically well qualified and certified personnel of OEM as per the requirements.
- b. Contractors shall not outsource any part of the contract to any other vendor/third party contractor except OEM without prior permission of AAI.

2.5 Quality Assurance Standards

The OEM shall use Quality Assurance procedure compliant with Quality Assurance in system design, development, manufacturing, and installation and servicing- ISO 9001 Quality Management and Assurance Standards Part 3 – ISO 9001 Application and Development, Supply and Maintenance of software.

2.6 Reliability

To ensure high availability and high reliability, the offered equipment design by the bidder and its OEM partner shall employ the most suitable engineering techniques, materials and dependable components, field proven design and rigorous inspection during manufacturing to ensure a very high MTBO (Mean Time between Outage) and MTBF (Mean Time between Failure) of equipment.

2.7 Environmental Conditions

The offered equipment shall be capable of maintaining its guaranteed performance when operating continuously for 24 hours a day and 365 days a year without any deviation in quality or degradation of system performance and all the parameter detailed in these specifications shall be guaranteed over the following environmental conditions:

i) Indoor Equipment:

Operating Temperature: 0 degree to + 40 degree Centigrade.
Relative Humidity: 80% up to 35 deg. centigrade.

ii) Outdoor Equipment:

Operating Temperature: -10 degree to + 50 degree Centigrade.
Relative Humidity: 90% up to 35 deg. Centigrade

iii) Storage Temperature: -10 to + 70 degree Centigrade

3.0 AUTOMATIC BOOM BARRIER

SCOPE

This section covers the detailed technical specifications of automatic raising boom barriers, power/ control cables and associated accessories & components including their installation, testing, commissioning and handing over to AAI as per standard procedures.

SYSTEM CONFIGURATION

Length of Barrier Boom	:	of suitable length to suit Site condition.
Drive Mechanism	:	Electro-mechanical drive unit consisting of motor, gears, shafts etc. for intensive/ heavy duty use and capable to generate sufficient torque for lifting/ lowering of boom.

Control Panel	:	Control Panel shall operate the boom through local push button on itself as well as remote control push button switch on respective nearest watch tower.
Housing	:	The control unit to be housed under dust and water resistant box with minimum IP 54 protection. The thickness of steel sheet (304/312 grade) should not be less than 1.6 mm and size of housing boxes as per manufacturer's standard.
Operation	:	Operation of boom barrier shall be smooth (without bounce/ jerks) while open and close.
Power-off Operation	:	The barrier can be raised and lowered by releasing the boom lock with key type mechanism.
Safety	:	Optical beam sensor to detect presence of vehicles and inversion of boom movement and other protection features as per OEM's standards.
Barrier Boom	:	The boom shall be rectangular/circular shape made of white painted aluminium bar with red adhesive reflecting strips and provided with "STOP" guidance board. It should be strong and self-sustainable.
Arm Rest	:	Suitable SS (304/312 grade) arm rest to be provided as per manufacturer's standard.
Power Supply to Control Panel	:	1-Phase, 230 Volts, 50 Hz, AC power supply.
Opening Time (Up to 90 Deg)	:	< 6 Sec for 4.00 / 3.00 Mtr.
Duty Cycle	:	100%, Intensive Use
Working Temperature	:	-20 to +55 Degree Celsius
Other Features	:	Stand to steadiness of boom in rest position for suitable Meter, Push Button, LED Flash Lights, compatible/ integrable with access control system etc.
Installation	:	Control Panel/ Holding stand to be installed by making suitable PCC platform as per standard engineering practice and the instruction of Engineer-In- Charge.

- a) Specified sizes of 1.1KV grade XLPE insulated PVC sheathed armoured Aluminum / Copper cable of 2/3 cores shall be confirmed to IS: 7098 (Part- I) with up to amendments.
- b) Laying of specified sizes of 1.1KV grade cables on existing surfaces/directly in ground with sand cushioning & protective covering /in existing pipes/ in existing

open ducts including storage, handling, testing before & after laying etc. to be carried out as per CPWD specifications.

The technical specifications given above are for general guidance only and standard specifications of manufacturer are acceptable subject to the condition that these specifications meet the technical /functional requirement.

4.0 MOTORISED SLIDING GATE

SCOPE

This defines the specifications for motorised sliding gate at entry point operational area consisting of Design, fabrication, Supply, installation, testing and commissioning of electrically operated Sliding gates of required sizes with all required accessories and other related works.

SYSTEM CONFIGURATION

Gate Type	Electrically Operated remote controlled single leaf side opening Crash rated Automatic sliding Gate made of Mild Steel hollow tubular section
Gate Clear width	As per site condition
Gate clear height	3000 mm
Overall width of the gate	As per site condition
Number of leaves	One
Opening Direction	Unidirectional
Gate Design	
Pattern	Standard MS rectangular/square section, torsion free fully welded unit.
Gate frame	Horizontal and vertical profile shall be fabricated with MS section fully welded unit of size minimum 100mm x 100mm x 3mm
Inside Vision Protection	Horizontal and vertical profile from the bottom end of MS Gate (i.e upto 2.5 mtrs from bottom level) covered with 2mm MS Plate from outer side to protect with inside vision
Safety Post	Safety strike with MS post made of 100x100x3mm profile section galvanized limit stop on both side
Manual gate for pedestrian	Small opening of size 2Mtr x 1Mtr (HxW) for manual operation for pedestrians.
Supporting Stopper's	M.S supporting stoppers of adequate dimensions as per the design requirement and shall be fabricated with MS section fully welded unit of size minimum 100mm x 100mm x 3mm
Bottom Rail/Track	C channel & 20mm round polished bar
Bottom rollers / wheels	Galvanized wheels 120mm dia with ball bearings and axle with lubrication point or EIC approved
Surface Finish	Painting of MS gate shall be with one coat of red oxide or anti corrosive paint after that

	two coat of epoxy paint or better quality of approved colour.
Guide rollers	Nylon rollers mounted on both side of column providing lateral support & smooth movement to the gate leaf
Manual operation in case of power failure	Required
Provision of 300mm concertina coil/killer on the top of the full length of gate	Required
Complete with control panel, safety sensors and flash light, cable of suitable size according to load identified from nearest DB to control panel (approx.. 30 Mtr) and all accessories etc.	Required
Requirement of Test Certificate	Physically crash tested sliding gate through TRL/MIRA/KARCO/CTS under std of ASTM/DOS/PAS 68/IWA 14:2013 criteria with 0 meter penetration having the strength to withstand the front impact of minimum 6.8 Ton (or more) vehicle travelling at the speed of 48 kmph with 0 mtr penetration. The product should be manufactured by the OEM in their principal factory with same address mentioned in the physical crash certificate.
Drive unit	Rack driven rugged and powerful drive unit with integral electronic control unit
Travel control system	Control unit with limit switches to sense, Open and Close positions.
Duty Cycle	Intensive Use
Working Cycle	100%
Power Supply Vac/Vdc	415V / (24 VDC) as per design
Release system for manual opening	yes
Control Switch	Three station push button
Safety devices	Speed control, safety sensor/pair of photo cell eye, flash light, key switch, cams emergency release. Irreversible electromechanical unit to keep gate securely locked, safety clutch etc
Highly compact dimensions & extremely silent operations	Yes
Motor protected by internal thermal switch	Yes
Advance electronic control unit permits/allows operating time adjustment, partial opening. Automatic closing, step by step control stop safety, reverse safety	Yes
MPS startup at maximum power permits motor to overcome any initial friction caused by ice. Dust etc	Yes

Civil work	All civil work required to install the gate shall be suitable to hold gate, cutting of road & fixing of channel, concrete work complete as per OEM recommendations and as per site requirement including all excavation shall be in the scope of EPC contractor. This also includes various civil work without damaging other structure with proper cleaning of all the debris from site after work of all as per site requirement.
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GENERAL CONDITIONS/SPECIFICATIONS:

1. The gate shall be fabricated as per the approved drawing.
2. The gate shall be operated from the control panel in the security cabin and also manually in case of failure of power supply/control system.
3. The control panel shall be provided with all protective devices like Over load relay/contactors, single phasing preventer, indicating lamps, push buttons etc.
4. The gate shall be provided with a flashing lamp/buzzer during operation of the gate.
5. The gate shall have an electronic breaking device for ensuring immediate stop.
6. Suitable number of MS Gate supporting /guide post shall be provided.
7. Suitable sized control cable shall be laid in the 50mm dia. GI pipe between the control panel and the drive unit. The pipe shall be buried at a depth of min. 200mm and shall be covered / finished with cement concrete of 1:2:4.
8. All the details/signs/descriptions if any shall also be painted/written/pasted on the gate.
9. All the interconnecting cable between control panel and unit shall be the contractor's responsibility.
10. All other works related i/c all civil works like RCC beam for bottom rail, foundation for supports etc. for the satisfactory functioning of sliding gate shall be the responsibility of the contractor.
11. The contractor shall submit the drawing for approval of the Engineer-in-Charge. Fabrication shall be commence only after drawing approval.

SUPPLY AND LAYING OF CABLES, DWC HDPE PIPE, CONDUITS, EARTHING, CONTROL PANELS shall be as per the relevant specifications mentioned in other paras of technical specifications.

BAGGAGE HANDLING SYSTEM (BHS)

11.0 TECHNICAL DESIGN & SPECIFICATIONS FOR BAGGAGE HANDLING SYSTEM (BHS)

1.0 SCOPE OF WORK

The scope of work in this Tender covers- Design, supply, installation, supervision, testing & commissioning of arrival and departure passenger baggage handling system of Terminal Building. It includes all materials, labour, tools, Engineering, supervision, installation, calibration, adjustments as required for commissioning of the baggage handling system also minor civil works necessary for satisfactory installation of the system.

The scope of work shall briefly cover the following:-

1.1 ARRIVAL PASSENGER BAGGAGE CONVEYOR SYSTEM.

- i) Design, Supply, Handling, Assembling, Installation, Testing & Commissioning of endless, horizontal, slat type Arrival Baggage Conveyor/Carousal as per specifications contained under this tender & generally in accordance with approved drawing, specifications etc as required.
- ii) Design, Supply, Handling, Assembling, Installation, Testing and Commissioning of Motorized Rolling Shutters, Draught Curtains, limit / emergency switches etc. as required and as specified.
- iii) Design, supply, installation, testing & commissioning of BHS control panel including providing power & control cabling from control panel for friction drive unit of the conveyor, emergency switches, limit switches, earthing etc. as required.

1.2 DEPARTURE BAGGAGE CONVEYOR SYSTEM:

- i) Design, Supply, Handling, Assembling, Installation, testing & commissioning of slider bed type Departure Conveyor System comprising of Weighing, & Despatch Conveyors including Collector / Take away as per approved drawing.
- ii) Design, Supply, Handling, Assembling, Installation, testing & commissioning of BHS Control panels i/c Providing power & control cabling/ wiring from control panel to all drive units of Conveyors, limit / emergency switches, Rolling shutters, check-in counters,
- iii) Design, Supply, Handling, Assembling, Installation, Testing and Commissioning of Motorized Rolling Shutters, Draught Curtains etc. as required.

1.3 All civil works, such as equipments foundation, cutting and making good holes, grouting of channels, bolts as required.

- i) Provision of supports / clamps for equipments, cables etc. wherever required.
- ii) Provision of canopies in outside areas.
- iii) Wiring, inter-connection, terminations etc. inclusive of all materials and accessories, necessary to comply with the regulations as well as proper and trouble free operation of the equipment.
- iv) Necessary testing equipments for testing and commissioning of complete BHS system.
- v) Provide safety features and mandatory provisions for public as per latest IATA standard.

2.0 DRAWINGS

The Baggage Handling System shall be provided as per the conveyor layout drawing enclosed.

3.0 SYSTEM CONFIGURATION

The proposed BHS system shall consist of, but not limited to, the following components:

- a) Check-in Island: 1 No.
 - For 08 nos. of check-in counters.
 - Integrated Scale/weighing conveyor for each counter.
 - Weighing scanner for each counter with displays for both airline staff & Pax.
 - BHS operator control panel for each counter,
- b) Conveyor system shall consist of, but not limited to, the following components.
 - Collector/Takeaway conveyors,
 - Dispatch Conveyors,
 - Transport conveyors,
 - Fire retardant Roller Shutter,
 - Draught Curtains, etc.
 - Gravity Roller
- c) Arrival Reclaims carousels: Endless Re-claim Carousels: Total 02 nos.(Approx 51 Mtr)
- d) All control systems of BHS with PLCs
- e) System Integration: shall consist of, but not limited to, the following components:
 - Integration with Fire Alarm system
 - Integration with Access control
- f) Any other system integration as required for successful commissioning of the system.
- g) Platform & Steel works: shall consist of, but not limited to, the following components:
 - BHS support structures & platform, canopy
 - Crash barriers,
 - Any other steel work as required to successful commissioning of the system,

4.0 DESIGN CRITERIA FOR ARRIVAL AND DEPARTURE BAGGAGE HANDLING SYSTEM (BHS).

4.1 (a) Conveyor system shall be design for handling passenger baggage

Length(mm)—900(Max), 450(Min)

Width(mm)- 750(Max),400 (Min)

Height(mm)-300(Max),150(Min)

(b) Normal live load shall be 35 kg / linear meter

(c) Following Baggage size of limiting weight are classified as odd-size and are not acceptable by system:

- Bigger than 900 mm x 750mm x 300mm.
- Smaller than 450mm x 400mmx150mm.
- The types of baggage include flexible baggage with strings, handles.

- (d) The system offered shall be designed for trouble free operation for a continuous duty cycle, round the year with nominal operating time 20 hrs per day.
- (e) The conveyor shall be so designed that it is capable to start and stop with full baggage rated load without tripping or cause any damage to associated components of the system.
- (f) Standard speed rate : As specified for Arrival Carousel and for different components of Departure Conveyors.
- (g) Curve Radius: 1500 – 1700 mm on the centerline of the Arrival carousel
- (h) The system offered shall not transmit any vibration to the buildings and nearby flooring or shall be minimal.
- (i) The design of the system shall be user friendly and provide maximum accessibility and convenience for operation and maintenance. Prime consideration to be given the safety of the passenger baggage, safety to passengers and personnel

4.2 NORMS AND REGULATIONS

The BHS should comply with IATA regulations.

4.3 NOISE LEVEL

The proposed system has to be designed and installed to minimize the generation of acoustic noise levels. Noise levels at 1 m from any part of the equipment should not exceed the following values or ambient noise level of airport whichever is higher:

Public areas	=	65 dB (A)
Non-public areas	=	75 dB (A)

5.0 SPECIFICATION FOR ARRIVAL BAGGAGE CAROUSEL SYSTEM

Specification for endless, race track type, horizontal (**slat type conveyor**) with flat overlapping slats to deliver in-bound passenger baggage's and collection of baggage's in the Arrival area shall be as under:

a)	Type	Heavy duty endless, race track type horizontal (flexible overlapping slat type) with all accessories, materials, protection devices, and soft starter mechanism ensuring smooth flow of baggage's. The system design should be such that it is easy to maintain. The baggage's shall be manually loaded in the break-up area and unloaded in the baggage claim area.
b)	Length / Shape of conveyor	The shape of the conveyor shall be as per the drawing enclosed. The loop length shall be measured along the center of the carousel.
c)	Overall frame size	As per OEM Standard.
d)	Useful width	Min. 950mm

e)	Height	450mm from the finished floor level which is to be considered as level 0.00
f)	Curve radius	1500 - 1700mm on the center line of Carousel.
g)	Slats & slat carrier	The overlapping slats shall be as per OEM design, black in colour with smooth top. The material of slat shall be of PVC / PU/ Rubber of high quality made of not less than 5mm thickness. The black colour slat shall be flexible, antistatic and be flame retardant. The slat carried support shall be minimum 3.0 mm thick fabricated from MS sheet duly painted.
h)	Emergency Stops	Provision shall be made in Panel and at three other locations of conveyor in the passenger baggage claim area.
i)	In fill	Infill should be marine type termite proof & fire-retardant plywood covered with synthetic carpet of approved shade (preferably green) to provide and aesthetically pleasing surrounding. There should be opening (with cover) for maintenance staff to access the system components.
j)	Noise	As per Para 4.3 of specifications. Noise level shall be measured as per procedure given under Para 9.3 of this specifications.
k)	Drive section	The drive mechanism shall be based on Friction Drive concept where a drive belt that engages on the chain blocks on one side while spring loaded precision wheels are engaging the chain block other side of the chain. The design shall be able to take higher load and with minimum slips between the chain blocks & the drive belt even when the load are increased. The drive unit shall be compact & it shall be possible to mount on the finished floor without any pit for drive. The drive unit shall be compact & it shall be possible to mount on the finished floor without any pit for drive. The drive unit shall be contained within the conveyor frame. The drive units and the guide frame for chain blocks shall be factory assembled in an integral base frame so that there is no mismatch with interfaced track units. The motors shall be of suitable HP with soft starting mechanism worn gear reducer fitted directly on the drive pulley, class F insulation, continuous rating operating on 415V + 10%, 50HZ, AC supply. The drive motor shall be IE-3 class with IP – 55 protections.
l)	Chain	The chain shall be suitable for the type of drive specified and shall consist of large robust cast aluminum links or as per OEM having corrosive resistant property or as per design of the manufacturer, Fabrication of chain shall be such that no lubrication is required. Chain tensioning required should be minimum and if required, the same should be possible and can be done without tooling.
m)	Framework	The framework shall be of mild steel profiles cross plate and side frame plates, duly painted. All parts shall be bolted or welded together to form a complete framework of straight, curved and drive unit sections. The formed

		sheet frames shall not be less than 3 mm thick.
n)	Supports	The supports joining the sections shall be equipped with adjustable bases in order to level the supports during erection. All sections shall be bolted together i.e. standard, adjustment and curve sections shall be all bolted together with the drive sections to form the finished structure. Structural supports for the tracks will be spaced on a maximum of 1.5 meter intervals at loading area. Adjustment support legs shall be used as per design of OEM. Anti vibration blocks shall be provided as required.
o)	Chain Track	The chain& chain wheels shall be guided in a MS epoxy painted or galvanized central track.
p)	Take up Section	The chain shall be tensioned by two screwed rods attached to two sections of inter sliding track. The outer frame and track shall be not less than 700 mm long initially and reduced to the required length after less than 700 mm long initially and reduced to the required length after the chain is fully tensioned at site OR as per manufacturer standard as required.
q)	Inner side wall	The conveyor shall be provided with sidewall guard raised the inner side to prevent falling of baggage. On the loading side of conveyor, the inner side guards shall be of 3 mm thick MS sheet duly epoxy coated of height up to 350 mm (nominal)/as per OEM & in the passenger area the guards shall be of 1.6 mm \pm 0.1 thick SS sheer of 70 mm height above belt top. NOTE: At loading area the conveyor should be provided with additional supports and suitable bumpers to withstand the impact caused while loading the baggage on the conveyor which can prevent it from further damage.
r)	Trim / Fascia finish	All the rotating parts (motors, roller etc.) shall be covered and not accessible (exposed) directly. Instead of trim / fascia covering, under-guarding cover for the conveyors, which have the lowest section of conveyor height 700 mm above the ground level, shall ensure he maintenance and safety aspects.
s)	Toe Kick plate	The toe kick plate shall be minimum 1.6 mm \pm 0.1 mm thick Stainless steel sheet in passenger area.
t)	Bearings	All bearings shall be self-aligned sealed type antifriction pre-lubricated greased for life. The bearing selected shall be for continuous duty and for service and loading of conveyors.

6.0 SPECIFICATIONS FOR DEPARTURE BAGGAGE CONVEYOR SYSTEM

6.1 WEIGHING SCALE CONVEYOR

(a)	General	An integral baggage weighing scale conveyor equipped with illuminated push button for introduction of baggage into dispatch conveyor (after baggage had been weighed & tagged) and subsequently feed the baggage into take away conveyor system. The weighing conveyor including, frame, belts, side guard are mounted directly on top of weighing scale and it has to be made full proof from tempering by the external agencies/factors. The conveyor weight is permanently balanced within the weighing system to provide Zero indication when the conveyor is empty. Complete unit shall be easy to maintain. The weighing conveyor shall be calibrated & stamped from weight & measures deptt. And its certificate has to be provided.
b)	Type of Conveyor	Heavy duty Slider bed type Conveyor
c)	Useful width	Width shall not be less than 650 mm.
d)	Overall frame size	Maximum up to 800mm OR As per system design of OEM and functional requirement
e)	Height	As per system design of OEM and functional requirement.
f)	Speed	As per system design of OEM and functional requirement
g)	Bag size	As per Para 4.1 (a)
h)	Bed	Bed shall be made of 3 mm thick galvanized or epoxy coated mild steel sheet
i)	Length	1.2 mtr nominal
j)	Tension adjustment	The system shall be provided with suitable positive and precise tension adjustment mechanism without changing the conveyor length. Accuracy class : C3 to C6.
k)	No of load cell and load cell capacity	4 Nos. of high resolution load cells, each of suitable capacity
l)	Belt type	2 ply 3mm (Min.) thick polyester black colour carcass PVC rough top, flame retardant, antistatic robust, flexible capable of providing continuous service, and of very low friction type belt
m)	Drive& pulley	Adequate friction coefficient between slider belts and bed shall be considered for calculating the capacity of driver unit. Motorized drum driver pulley shall be used. It shall be mounted on the head end.
n)	Power supply	415V \pm 10%, 3Phase 4 wire 50Hz AC Supply.
o)	Control logic & Protection	PLC Control (part of panel). Refer specification contained under the section for control panel.
p)	Frame supports and	The conveyor structure for supporting rollers, drums, slider bed etc. shall be fabricated from MS formed channels/angles/strips not less than 2 mm (minimum) thick or of angle frame as required. The conveyer frame and its supports shall be mounted on the framework of weighing scale.

q)	Trim/ fascia covering/ finishing	Formed plate side fascia covered with SS-304 grade stainless steel of 1.6 ± 0.1 mm (minimum) thick. The bottom level shall be just above ground finish level and top level shall be within the level of sidewall. This shall be suitably interfaced wherever side-raised wall is provided. All SS/MS connection shall be smooth without opening or projections on which bag tags, straps etc. may catch. All flat head screw used to attach stainless steel shrouding such as horizontal portion attached to conveyor belt must be completely countersunk so that no portion of screw head is above the adjacent surface. Grinding or filling of screw heads shall not be done. Field welding of any SS trim element shall not be done. Additionally, no blemishes of the SS trim element shall be accepted. This inclusive those caused by poor manufacturing practices as well as those caused in the field attempts to remove any blemish.
r)	Pulley	The system shall comprise of Tail pulley fitted with precision bearing operating on steel shaft. Head pulley & tail pulley shall be sized as per requirement.
t)	Return/ Snub rollers	Manufacturer bottom return rollers of standard design feature are accepted. If provided it shall be fitted with internal grease sealed bearing operating on steel shaft to conveyor side plates.
u)	Side Wall / Guard	A raised sidewall made of up on operator side 70mm (min) and on other side 225mm (min) height of 1.6 ± 0.1 mm of SS-304 grade stainless steel sheet or better design as per OEM shall be provided to prevent falling of baggage & to guide / channelize the baggage. The guard section shall have a smooth inner finish free from projection, fastening; weld metal, which may cause interference to flow of baggage. The width between the sidewalls at both the ends shall match the adjacent section.
v)	Accessories and Controls	In built electronic weighing scale complete with dual 7-segment display unit, interconnections etc. shall be provided. The capacity of scale shall be up to 200 kg with scale graduation of 0.1 kg and accuracy of $\pm 0.05\%$. Each weighing conveyor system shall have individual Push Button, shall also have an ON/OFF switch of display unit and shall incorporate the following controls. i) Balance; to check and correct zero balance. ii) "Check" - "Zero" to restore the weight to Zero. iii) To check the 7 segment of digital display iv) LCD dual display unit to indicate weight to Ticketing staff as well as passenger.
w)	Calibration	Calibration of weighing conveyor by weight & measurement department of Govt to be provided by agency.

6.2 **HOLD/ DISPATCH CONVEYOR.**

a)	Type of Conveyor	Heavy Duty Slider Bed Belt Conveyor
b)	Length of Conveyor	Each 1.2 mtr nominal.
c)	Useful belt width	The Belt width shall be selected such that it fits within the frame, without much side play and shall match with that of integrated weighing conveyor

d)	Overall frame size	Shall match with integrated weighing conveyor
e)	Height	As per system design of OEM and functional requirement. Suitably sloped for easy transfer of baggage from one section to adjoining section etc.
f)	Speed	As per system design of OEM and functional requirement
g)	Bag size	As per para 4.1 (a)
h)	Normal live load	35 Kg per linear meter.
i)	Belt type	2 ply 3 mm minimum thickness polyester black color carcass PVC smooth/rough top, flame retardant, antistatic, robust, flexible, capable of providing continuous service, and of very low friction type belt. Diamond cut belt of 7.5 mm thickness is also acceptable.
j)	Bed	Bed shall be made of 3 mm thick galvanized or epoxy coated mild steel.
k)	Power Supply	415V \pm 10%, 3Phase, 4 wire, 50Hz AC Supply.
l)	Take Up	Screw take up.
m)	Pulleys	The system shall comprise of drive pulley (part of drive unit), Head and tail pulley, to meet the design parameters. The pulleys shall be complete with shaft, bearing, mounting brackets etc. as required. The requirement of take up pulley & snub pulley shall be as per manufacturer design.
n)	Return Roller	If required and provided, the bottom, return rollers shall be of nominal diameter 50 mm (O.D.) with internal bearing to meet the design parameters.
o)	Vertical baggage guide / tipping device	Suitable arrangement shall be provided at each diverter junction of the system & suitably located for easy guidance/ tipping/ diversion of baggage from dispatch conveyor to main conveyor and one section to another wherein the direction of baggage flow is different
p)	Frame and supports	The conveyor structure for supporting rollers, drums, slider bed etc. shall be fabricated from MS formed channels/angles/strips not less than 3 mm or of angle frame as required
q)	Support	Support shall be adjustable and shall include provision for attaching directly to floor.
r)	Noise level	The noise level produced by the system shall be as per para 4.3
s)	Tension adjustment	System shall be provided with suitable positive and precise tension adjustment mechanism.
t)	Bearings	All bearings shall be self-aligned sealed type anti-friction pre-lubricated greased for life. The bearing selected shall be for continuous duty and for service and loading of conveyors
u)	Drive Unit	Adequate friction coefficient between slider belts and bed shall be considered for calculating the capacity of drive unit. Motorized drum drive pulley shall be used. It shall be mounted on the head end.
v)	Control Logic	PLC Control (part of panel) refer specification contained under the section for control panel.
w)	Trim /facia covering / finishing	Formed plate side facia covers with SS-304 grade stainless steel of 1.6 mm \pm 0.1 mm thick. The bottom level shall be just above ground finish level & top level shall be within the level of side raised wall. This shall be suitably interfaced wherever side raised

		wall is provided.
x)	Side wall / Guard	A raised side wall made of up on operator side 70 mm and on other side 225 mm 1.6 mm \pm 0.1 SS-304 grade stainless sheet or a better design as per OEM shall be provided to prevent falling of baggage and to guide/channelize the baggage. The guard section shall have a smooth inner finish free from projection fastening weld metal, which may cause interference to flow of baggage. The width between the side walls at both the ends shall match the adjacent section.

6.3 TAKE AWAY – DELIVERY (TRANSPORT) CONVEYOR

a)	Type of Conveyor	Heavy Duty Slider Bed Belt Conveyor
b)	Length of Conveyor	As required and specified in drawing
c)	Useful width	950mm (Min.), The belt width shall be selected such that fit within the frame, without much side play.
d)	Overall frame size	Maximum up to 1050 mm OR As per system design of OEM and functional requirement
e)	Height	400 mm from floor level except certain specific applications as per approved drawings, to create easy flow of baggage from one section to adjoining section etc. As required.
f)	Speed	21 to 25 meter per minute / as per system functional requirement.
g)	Bag size	As per Para 4.1 (a)
h)	Normal live load	35 Kg per linear meter
i)	Belt type	2 ply 3mm minimum thickness polyester black colour carcass PVC smooth top, flame retardant, antistatic robust, flexible. capable of providing continuous service and of very low friction type belt.
j)	Bed	Bed shall be made of 3 mm (min) thick galvanized or epoxy coated mild steel sheet.
k)	Power Supply	415V \pm 10%, 3Phase 4 wire, 50HZ AC Supply.
l)	Take up	Screw take up
m)	Pulleys	The system shall comprise of drive pulley, Head & tail pulley, take up pulley and snub pulley to meet the design parameters. The pulleys shall be complete with shaft, bearing, mounting brackets etc. as required.
n)	Return Roller	Bottom, return rollers of nominal dia. 50 mm (OD min.) with internal bearing to meet the design parameters.
o)	Vertical baggage guide/tipping device	Suitable guide / diversion roller shall be provided at each diverter junction of the system and suitably located for easy guidance / tipping / diversion of baggage one section to another wherein the direction of baggage flow is different. The material for guide roller shall be stainless steel & adequately sized.
p)	Frame and supports and cross members	The conveyor structure for supporting rollers, drums, slider bed etc. shall be fabricated from MS formed channels/angles/ strips 3 mm (minimum) thick or of angle frame as required.
q)	Support	Support shall be adjustable & shall include provision for attaching directly to floor.
r)	Support spacing	Not more than 3 Mtrs except in loading area where spacing shall not be more than 1.5 Mtrs.

s)	Noise level	The noise level produced by the system shall be as per para 4.3
t)	Tension adjustment	The system shall be with precise tension suitable positive and adjustment mechanism.
u)	Bearings	All bearings shall be self-aligned sealed type antifriction pre-lubricated greased for life. The bearing selected shall be for continuous duty and for service and loading of conveyors.
v)	Starting method	Refer control panel specifications.
w)	Drive Unit	Adequate friction coefficient between slider belts and bed shall be considered for calculating the capacity of drive unit. Shaft mounted speed reducer driven by totally enclosed fan cooled geared motor suitable for operation for 415 V 50Hz 3 phase AC with class 'F' insulation (minimum). The motor shall be of low energy loss type. The drive motor shall be IE-3 with IP 55 protection. Anti-vibration. Pads shall be used wherever necessary to prevent excessive vibration. The drive unit, its gear assembly, shaft mounting, drive pulley etc. Shall be factory assembled on an integral frame for precise alignment and operation.
x)	Control Logic & Protection	PLC Control (part of panel) refer specification contained under the section for control panel.
y)	Trim/facia covering/finishing	Formed plate Side facia covers with SS-304 grade stainless steel 1.6 mm \pm 0.1 mm thick in passengers area and formed plate side covers made of 3 mm thick MS sheet with epoxy coated paint finish in non-passenger area. The bottom level shall be just above ground finish level & top level shall be within the level of sidewall. This shall be suitably interfaced wherever side-raised wall is provided.
z)	Side wall / Guard	One side raised sidewalls of 300mm height made of 1.6 mm \pm 0.1 mm thick stainless steel SS-304 grade sheet, in passenger area and one side raised sidewall 300 mm height made of 2 mm thick MS sheet with epoxy coated paint finish in unloading area, whereas in the balance areas both side raised sidewall 300mm MS sheet with epoxy coated paint finish. The guard section shall have a smooth inner finish free from projection, fastening, weld metal, which may cause interference to flow of baggage. The width between the sidewalls at both the ends shall match the adjacent section. For ease of maintenance, side guard panel shall be bolted or inserted with other mechanism on the conveyor frame.

6.4 **GRAVITY ROLLER CONVEYOR**

i)	Roller length	1500mm/ 2000 mm (nominal)/ to match with the site requirement of AAI or as per manufacturer's recommendation to match with take way conveyor.
ii)	Over all width	To match with adjacent conveyor.
iii)	Pitch & dia of roller	60/65 mm pitch / dia or as per manufacturer's recommendation.
iv)	Length of the section(s)	Required as per drawing/design.
v)	Quantity	Required as per drawing/design.
vi)	Roller capacity	35 kg per meter
vii)	Height	Suitably matched and sloped
viii)	Support	The support of gravity roller shall have provision to adjust the height as per site for minor ground level.

		The support shall be spaced not more than 3 Mtrs/ as per OEM.
ix)	Conveyor frame work	Fabricated and formed out of 3 mm (minimum) thick sheet steel or suitable angle frame with epoxy coated paint finish.

6.5 **END COVERS**

End covers shall be provided at all the dead ends of conveyor sections made of 1.6 mm \pm 0.1 mm thick SS-304 grade sheet cover in passenger area and 3 mm thick epoxy coated MS cover in non-passenger area, with ventilation arrangement for safety protection.

7.0 **OTHER INSTALLATIONS & ITEMS**

7.1 **ROLLING SHUTTERS**

i)	Material	Fabricated from MS of deep convex corrugations with side channel guides plate brackets. All MS shall be suitably painted / epoxy coated matching with side wall /frame colour and as approved by Engineer-in-charge. Rolling shutters are required to be provided where the conveyors are entering the space within the terminal building.
ii)	Size	To suit the opening in wall shall be provided by AAI.
iii)	Auto Operation	The rolling shutters shall be provided with suitable rated geared motor directly coupled to the shaft of the shutter. The drive motor shall be IE-3 with IP 55 protection. Up & down movement of the rolling shutter shall be controlled by either limit switch or sensors. Interlock with conveyor motor starter so that the conveyor would start only when the shutter is in full open conditions. Down movement of the shutter could be done only with OFF switch of Conveyor System
iv)	Manual Operation	Provision for manual operation of shutter shall also be made with separate push buttons for up and down movements.
v)	Manual locking	Provision to lock the shutter shall be made.

NOTE: Necessary control provision shall be added in MCC for the complete function of rolling shutter as described above.

7.2 **DRAUGHT CURTAIN:**

Draught curtain shall be provided across the openings, through which conveyor is taken outside. It shall be fabricated with 3 mm thick nylon rubber of adequate size with stagger layer (neoprene material and arranged with each strip overlapping the adjacent strip by 50% giving an overall overlap 100%) will be hanged from top of the opening with the suitable SS sheet covers.

7.3 **WIRING/ CABLE WORK:**

Cable work and Wiring from control panel to various conveyor motors, remote control point and limit switches shall be provided. The power cable for motor shall be armoured and of adequate size to carry the full load current continuously and shall be of copper. Control wiring inside the control panel shall be copper and the size shall be as per standard practice followed by manufacturer. However, the size of the control wiring

carried out at site i.e., from control panel to limit switches, remote emergency off switches, Buzzers, sensors etc. shall be of adequate size copper cabling. The power and control wiring shall be fire retardant type and shall be laid on MS box type cable trays duly painted wherever possible or suitably fixed on the conveyor frame/floor through HDPE pipe as required.

7.4 EARTHING:

All the motors shall be provided with two separate earth connections by drawing suitable size conductor wires from the control panel earth connections. All switches, motors, structures etc. shall also be connected to the earth points as per the IS specifications which apply to the types of work.

7.5 PAINTING

All metal parts shall be completely cleaned of rust, carbon deposits and if applicable, welding residue, de-greasing and priming. Thereafter, it should be painted with synthetic enamel paint / powder coated to get even and desired finish.

- 7.6** Any sub component not specifically mentioned in the tender document (particular specifications/tender drawings) but required for successful commissioning of Baggage Handling System has to be provided by the contractor within the quoted cost.

8.0 CONTROL LOGIC & CONTROL PANELS

8.1 CONTROL LOGIC FOR DEPARTURE CONVEYOR SYSTEM

The control logic shall be designed and provided by the Contractor to meet the system requirement as specified in technical / particular specifications. However, the following are provided as minimum criteria for guidance to the tenderers.

1.	ALARM AND DELAY START TIMERS	Whenever the system switched on to initiate the start function on each occasion a buzzer will be connected to the circuit (selectable timer 0-30 Sec) & which produce an audible alarm. The buzzer sound shall be different from the fire alarm buzzer installed in the building. After 30 seconds the alarm will be turned off. Then the conveyor system would start functioning as per sequence indicated below: (i) Rolling shutter start opening (Upper & Lower limit switch shall be provided to ensure full opening/ extreme closing of Shutter). (ii) Take away conveyor (section close to gravity roller). (iii) Second, third take away section if planned & provided. (iv) Dispatch conveyor.
2.	DELAYOFF TIMER	One timer has to be incorporated into the circuit to Stop take away conveyors etc. after normal stop button is operated. The time selector is sufficient for the last luggage loaded at the check-in-counter to reach end & then the system will be either switched OFF. The OFF timer shall have a selectable/rating of 0-30 minutes minimum.
3.	EMERGENCY REMOTE OFF	The system shall have sufficient number (min 3) of remote emergency OFF push button (push to lock) suitably located in the area of Departure conveyor & baggage loading area for emergency stopping of the system. In addition to one OFF push button, at a location close to weighing conveyor shall be provided. When this switch is operated all timer circuit has to be bypassed & system should come to a grinding stop. Only after releasing the emergency Stop, the conveyor could re-start. A

		remote emergency OFF switch shall be suitably located near the break up area to avoid accumulation of luggage on conveyor & gravity roller. The departure conveyor should have sensors installed one in front of each feeder conveyor such that the sensor continuously monitors the flow of baggage's & at any point of time if baggage gets stuck or jammed in front of the transfer points, the sensor should trip the entire conveyor system with a fault indication signal & audio alarm. Similarly when there is baggage on the conveyor in front of the sensor installed opposite to the feeder conveyor, the feeder conveyor should not function till the baggage in front of the sensor has been cleared.
4.	DISPLAY BOARD	An integrated Mimic Display Board with the MCC shall be provided to indicate the status of each conveyor section(s). The mimic board display shall be fabricated with fibre glass board with proper shape of conveyor and LED indications. Two different coloured LED indication shall be kept for each section for Conveyor to show ON and OFF. Proper ventilation shall be incorporated in the system.
5.	BUZZER	The buzzer shall be electronic type and rated for 230 Volts 50Hz AC supply. Buzzer with 24V DC supply is also acceptable. One buzzer at baggage make-up area & one in passenger area shall be provided.
6.	ROLLING SHUTTER	The rolling shutter shall be operated by motorized gear assembly connecting directly to the shaft of the shutter. Up and down movements of the shutter shall be controlled by either limit switch or sensor.
7.	SENSORS	The programmable logic control shall be achieved through sensors placed at the required location. The control logic shall be such that If a particular section wherein baggage's to be delivered is not in working status then the baggage shall not be transferred to the adjoining section, by activation of necessary stop sensors of the feeding section which are placed at appropriate location of the section wherein the baggage move.
8.	REMOTE START / STOP	The system should be provided with remote start/stop station as per site requirement and to ensure safety of passengers & workmen.

8.2 CONTROL PANEL FOR DEPARTURE CONVEYOR SYSTEM

a)	Type of Construction	Cubicle type, indoor floor mounting compartmentalized, fabricated out of CRCA sheet steel of thickness 2 mm, duly powder coated. The panel shall be double door front, both side openable, accessible. All doors shall be provided with high quality neoprene rubber gasket. Door interlock feature with incoming power supply shall be provided as per manufacturer standard. The type of protection for enclosure of the panel shall be IP 42.
b)	Panel layout	Layout drawing shall be got Prepared by the contractor and approval obtained from the Engineer-in-charge before taking up the fabrication work.
c)	Incoming control unit	415 Volts 4 pole MCCB (micro processor type) of breaking capacity of 35 KA (Ics = 100% Icu) with over load, short circuit & earth fault protection. The rating of the MCCB shall be so selected that only about 80% of its full current carrying capacity is utilized for meeting the requirement of the specific application including future load of expansion of

		four more check in counters.
d)	Incoming Protection	i) Single Phase Protection ii) Phase reversal protection iii) under voltage protection
e)	Status Indication / display	Indication lamps (LED Type) in different colour for Three phases, power ON with protection MCB.
f)	Meters (Incoming)	a) Digital type Ammeter of required range with selector switch & current transformers. b) Digital type Voltmeter with selector switch and protection MCB.
g)	MOV & Switch	Necessary surge protection system (block 70KA minimum with neutral protection) shall be provided at control panel of conveyor with incomer switch.
h)	Outgoing for each section	MPCB of suitable current rating & breaking capacity of 10 KA for each motor and suitable MCBs for control wiring.
i)	Outgoing for rolling shutter	. 2 pole MPCB of 10 KA & suitable current rating for each shutter motor. . Interlocking with conveyor & limit switches/ sensors. . Auto-manual switches, separate push button for UP/DOWN movement of rolling shutters etc.
j)	Outgoing for each weighing scale & dispatch conveyor	MPCB of 10 KA & suitable current rating for each weighing scale conveyor & each of dispatch conveyor.
k)	Emergency stop	i) Provision shall be made in panel & at two other locations of take away conveyor. ii) Provision shall be made at one location closed to each of weighing conveyors. iii) The emergency stop button shall be "press to Stop" and release type.
l)	Alarm / Time delay	Provision for time delay start, duly interconnected with buzzer and start the sequence of conveyor
m)	Interlock & logic	A PLC based programmable logic to meet the operational requirement shall be worked out and got approved from Engineer-in-charge. Required number of sensors and other control devices shall be provided to meet the functional logical operation of conveyor along with sequential operation of feeder conveyor as required.
n)	Air Louvers	The central panel constructional feature shall have air louvers for proper ventilation
o)	Provision for future expansion	The incomer switch rating & control panel should have provision towards addition of switch gears, controls, cabling, wiring, etc. To accommodate the weigh-scale, dispatch & take away conveyor suitable for Four nos. Additional Check-in-counters in future.

Note. 1: Above given technical particular indicates minimum requirements and contractor shall examine accurate requirements of system and should design Control Panel accordingly. Standard product of manufacturer meeting international standard shall also be accepted.

8.3 CONTROL LOGIC FOR ARRIVAL CONVEYOR

A.	ALARM AND DELAY START TIMERS	<p>Whenever the system switched on to initiate the start function on each occasion a buzzer will be connected to the circuit (selectable timer 0-30 Sec) and which produce an audible alarm. The buzzer sound shall be different from the fire alarm buzzer installed in the building. After 30 seconds the alarm will turned off. Then the conveyor system would start functioning as per sequence indicated below:</p> <p>i) Rolling shutter start opening (upper& lower limit switch shall be provided to ensured full opening / extreme closing of shutter.</p> <p>ii) Arrival carousal</p>
B.	DELAY OFF TIMER	One more timer has to be incorporated into the circuit to carousal conveyor after manual stop button is operated. The time selector shall be sufficient for the last luggage loaded to make three round of the carousel loop and then the system will be switched OFF. The OFF timer shall be of selectable i.e 0-30 minutes.
C.	EMERGENGY REMOTE OFF	The system shall have four remote/emergency OFF push button (push to Lock) suitably located in the area of carousal conveyor for emergency stopping of the system. When this switch is operated all timer circuit has to be bypassed and system should come to a grinding stop. Only after releasing the emergency Stop, the conveyor could re-start.
D.	STATUS DISPLAY	As required.
E.	BUZZER	The buzzer shall be electronic type and rated for 230 volts 50 Hz AC supply. One buzzer at baggage make-up area and one In passenger area shall be provided.
F.	REMOTE STAR/STOP	The system should be provided with remote start/stop station as per site requirement.
G.	ROLLING SHUTTER	The rolling shutter shall be operated by motorized gear assembly connecting directly to the shaft of the shutter. Up and down movements of the shutter shall be controlled by either limit switch or sensor.

8.4 CONTROL PANEL FOR ARRIVAL CONVEYORS

a)	Type of Construction	Cubical type, outdoor floor/frame mounting compartmentalized, fabricated out of CRCA sheet steel of thickness 2 mm duly powder coated. The panel shall be front openable & accessible. All doors shall be provided with high quality gasket. Door interlock feature with incoming power supply shall be provided as per manufacturer standard. The type of protection for enclosure of the panel shall be minimum IP 55
b)	Panel layout	Layout drawing shall be got Prepared by the contractor and approved by the Engineer-in-charge before taking up the fabrication of work.
c)	Incoming control unit	415 Volts TPN MCCBs of breaking capacity of 25 KA ($I_{cs} = 100\% I_{cu}$) with over load & short circuit protection. The rating of the MCCB shall be so selected that only about 80% of its full current carrying capacity is utilized for meeting the requirement of the specific application.
d)	Incoming Protection	i) Single Phase Protection ii) Phase reversal protection iii) Under voltage protection
e)	Status Indication / display	Indication lamps (LED type) in different colour for Three phases & power ON with protection MCB.
f)	Meters (Incoming)	a) Digital type Ammeter of Required range with selector switch & current Transformers. b) Digital type Voltmeter with selector switch and protection MCB.
g)	MOV & switch	Necessary surge protection system (block 70KA minimum with Neutral protection) shall be provided at control panel of conveyor with incomer switch.
h)	Outgoing for Motor(s)	i) MPCB of suitable current rating & breaking capacity of 10 KA for each motor and suitable capacity MCBs for control wiring. ii) Soft starter for conveyor motor(s)
i)	Outgoing for rolling shutter	i) 2 Pole MPCB of 10KA & suitable current rating for each shutter motor. ii) Interlocking with conveyor & limit switches/sensors. iii) Auto-manual switches, separate push button for UP/DOWN mo.
j)	Emergency Stop	Provision shall be made in panel & at three other locations for each carousel in the passenger baggage claim area.
k)	Alarm / Time delay	Provision for time delay start, duly interconnected with buzzer and start the sequence of carousel.
l)	Interlock & logic	A programmable logic to meet the operational requirement shall be worked out and got approved from Engineer-in-charge. Required number of sensors and other control devices shall be provided to meet the functional logical operation of conveyor along with sequential operation of feeder conveyor as required.
m)	Air Louvers	The central panel constructional feature shall have air louvers for proper ventilation
n)	Other	Each Arrival carousel with separate PLC and panel.

9.0 GENERAL

9.1 The contractor shall engineer the Baggage handling system in accordance with the operating concept and performance specifications detailed herein.

- 9.2** The contractor shall furnish all equipment, parts, material, cables, conduits and any other supply required to satisfactorily effect the complete installation of the proposed system in a professional manner.
- 9.3** Fully competent workmen shall perform the work herein specified in a thorough professional manner. All materials furnished by the contractor shall be new, and shall confirm to applicable Indian standards or any International standards.
- 9.4** All equipment shall be held firmly in place except to the extent those proper performance criteria dictate the use of a resilient shock absorbing mounting. All fastening and supports shall be adequate to support their loads. All switches, connectors, outlets etc. shall be clearly, logically and permanently marked during installation. Adhesive Tape Markers and screen printed Markers liable to erasure during use will not be accepted.
- 9.5** Care shall be taken in wiring so as to avoid damage to cables and equipment. All joints and connections shall be made with resin-cored solder and/or with suitable connectors. All wiring shall confirm to the code of practice for electrical wiring/installations.
- 9.6** All cables shall be marked and colour-coded for easy recognition. Proper cable ends or plugs/sockets/multi-pin connectors, wiring shall be used for ending of each cable. Cable ends & terminating points shall be marked in such a way that it can be connected without referring to the Technical Manual every time.
- 9.7** While designing the system, particular attention should be given to the maintenance part. Mechanical designs shall be such that all the inside components of different units of the system are clearly visible & easily approachable for the purpose of testing & servicing the units. Modular concept using Plug-in type of modules shall be used. Wires used for interconnecting these PCBs shall be neatly bunched and routed. These wires shall be connected to the PCBs through multi-pin, plug-in type of connectors to facilitate easy removal of PCBs for servicing.
- 9.8** Test points are to be provided & marked at all the required points in the equipment units/installations. Voltages/data flow chart etc. shall be given in the technical manual.
- 9.9** Equipment should consist of plug-in sub-assembly units or cards so that fault could be located by eliminating/ substitution process.

NOTE :

- 1)** All other equipment shall meet the ISO standard and site work shall be of best engineering practice and approved by Engineer-in-charge.
- 2)** All drive motor shall be IE-3 with IP 55 protections.
- 3)** Cost of connectors and ALL other accessories on above scope of work/special conditions, required for completion of BHS work is deemed to be included in the quoted prices.

10.0 TESTING

10.1 PRE-DELIVERY INSPECTION/TESTING AT MANUFACTURER'S WORK:

Pre-delivery inspection of all the baggage conveyor equipments shall be carried out at manufacturer's work by authorized representative of AAI and the following tests shall be carried out.

- 1)** Dimensional checks of the different items shall be carried out as per technical data sheet/confirmed by contractor.

- 2) A prototype sample conveyor shall be got installed and the load test shall be carried out as per Para 5 for arrival conveyor and as per para 6 for departure conveyor. AAI's representative from the lot shall select the prototype sample at random.
- 3) Test certificate for the items procured from other origin shall be produced. These test certificates should be for testing as per NIT.
- 4) Various parameters like current, voltage etc. as per OEM recommendation shall be recorded during these tests. However noise level test shall be conducted at site after installation under performance test.
- 5) For departure conveyor the prototype sample to be installed will cover at least one of each types of conveyors i.e. weigh conveyor, dispatch conveyor & collector/ take-away conveyor. However, the straight lengths can be reduced.
- 6) For arrival conveyor the prototype sample to be installed will cover the basic shape of the conveyor as per layout enclosed in this NIT. However, the straight length can be reduced. Further, the 6 hours load testing shall be started after 4 hours no load run of prototype arrival conveyor.
- 7) Control panel shall be tested by connecting the equipment to the panel for its functionality as well as other routine tests.
- 8) Proper Test records including test results, video monitoring, photographs in proper reference to the requisite tests etc. should be made by contractor to preserve for subsequent verification, if required.

These documentary evidences should be signed by authorized representative of the concerned agencies.

10.2 TESTING OF INSTALLATION AFTER COMPLETION

- a) All units on their completion and before being placed in service, be subjected to a performance test followed by an acceptance inspection and tests to determine that all parts of the installation conform to the requirements and that all equipments function as required and the work has been carried out as specified.
- b) Tests and inspection shall be made by the contractor in the presence of the Engineer-in-Charge and the contractor shall notify the Engineer-in-charge in writing at least 21 day before the date of testing in order to facilitate arrangement for Engineering-in-charge to be present.
- c) All test weights, instruments and personnel to complete the testing & commissioning shall be provided by the contractor. Adequate supervision of the tests shall also be maintained.
- d) Corrective measures, if necessary, shall be carried out at no cost to the Authority.
- e) On successful completion of the installation of each of the passenger baggage handling system, following tests shall be carried out to the full satisfaction of the Engineer-in-Charge.
 - i) Earth continuity test of the installation.
 - ii) All relays, contacts, indicating lamp, inter-locking arrangement, operating mechanism, driving units, safeties, indicating instruments etc. shall be tested for their smooth and efficient operation.
 - iii) The Arrival carousal system shall be subjected to full load of 35kg/meter and shall run continuously for 24 hours without break down.
 - iv) The contractor is required to arrange all the tools, necessary loads and arrange for the required manpower. Nothing extra shall be paid for this test.
- f) The following load test is also required for departure conveyor:

The system shall be switched on and run for 8 hours on no load and then the system shall be subjected to full load of 35 kg/m with this load each conveyor will be subjected

to 10 starts and stops to confirm capability of operating under full load conditions. Starting and running current readings for the conveyors shall be noted.

g) Performance Test

After installation of the complete system, its operating capability shall be demonstrated. The contractor shall provide personnel, baggage, boxes, tools, weights etc. for testing. The performance test shall be conducted in the presence of Engineer-in-charge or his authorized representative for a minimum of 08 (Eight) hours continuously. The performance test shall include :-

1) Performance Test parameters

- i)** Check out of the operational and safety devices of the system using bags, boxes etc.
- ii)** Demonstrate the capability to handle required sizes and weights of baggage through the system without jamming or excessive toppling of baggage's.
- iii)** Demonstrate the capability of all conveyors being able to stat under full load.
- iv)** Measurement of all conveyor speeds using a standard device these measurements shall be taken with the system in a "no load" condition i.e. all conveyors running but without load. Any component not operation within 5 (Five) percent of design speed shall be re-worked to bring it to proper speed.
- v)** Noise limit test as per para – 4.3.

2) Correction of unsatisfactory operation.

During test period any deficiencies or variations in the design, fabrication or operation causing unsatisfactory performance shall be corrected to provide satisfactory performance. Manufacturer/ contractor shall have appropriate service personnel on site during the test period to service or adjust the system equipments as required.

3) Failure defined

A failure during any test period shall be defined as any design characteristic or malfunction of the furnished equipment or materials that damage baggage or reduce any operating rate below those specified. Conditions resulting from loading of improper baggage size or weight not included in the specification shall not be considered as failure.

4) Acceptance by AAI

After satisfactory comply of all test as specified above/on pre page, the conveyor system shall be accepted by AAI.

10.3 NOISE LIMITS

The equipment's design shall not generate noise which would be annoying or harmful to passengers and /or employees, both in the public areas and baggage make up areas. The baggage handling system equipment shall be so designed that the noise produced by the equipment does not exceed the limit. Specified under para 4.3, when measured at a distance of one meter. Testing shall be done as follows :

- i)** The baggage handling equipments shall be turned off.
- ii)** All others equipment (i.e. air-conditioning and other equipment) shall be ON and outside noise source shall be normal (aircraft and mobile ground equipment operating.)
- iii)** Noise level readings shall be taken at various points of the equipment throughout a zone of 1M distance from the equipment using a standard sound level meter.

- iv)** After the ambient noise level has been determined by steps (i), (ii) & (iii) above, the baggage conveyor system equipment shall be turned on and the total noise level shall be measured at the same points throughout the same that the ambient levels were measured, at different loads and at rated speed.

AUTOMATIC BI-PARTING SLIDING DOOR

12.0 TECHNICAL SPECIFICATIONS FOR AUTOMATIC BI PARTING SLIDING DOOR

Providing and fixing of frameless Automatic bi-parting sliding door operator for clear opening size as per design, modular design, including internal cover, edge sensors on both sides, Electro mechanical lock, light barriers and programmer switch complete in all respect. The track profile should be separate from the main profile for enabling reduction in vibration. Microprocessor control, self-learning, reversing when obstruction is encountered. Microprocessor-controlled control unit. It should be Self-learning, with adjustable parameters for opening and closing speed, hold-open time and opening and closing force. Class of protection IP 20. The glasses shall be of 12mm clear toughened frameless with polished edges. The system shall have constant power supply 230V, 50/60Hz (by others), for various opening sizes all complete as per design and instructions of Engineer-in-Charge.

Clear size of opening, height & width of the Automatic sliding door shall be as mentioned in drawings or as per design requirement.

1. GENERAL

The specially designed Automatic Sliding frameless door conforming to Indian or International Standards shall be supplied and fixed. Following minimum standard features shall be provided:

- a) A pair of bi-parting doors between side screens all fully glazed with frameless toughened glass for all-glass appearance
- b) The doors should be provided with electro-magnetic locks. Automatic control should be done by two infrared detectors, with a range of operating, control options and safety devices.
- c) The clear glass shall be of 12mm toughened safety.
- d) Aluminum clad steel columns will be used for achieving clear opening height. The system will be also equipped with Floor guide system, one pair of light-barriers and release device for sliding panels and side screens. All aluminum profiles will be in E6/C0.
- e) Quality Assurance: Manufacturer must be able to demonstrate compliance with ISO 9000: 2000 certification and also fulfils future European standards and regulations, TUV type tested, compliance with EU low-voltage directives.

2. MATERIAL

Minimum requirements for product shall be as given below:

- a) Motor : Direct current geared motor
- b) Drive: variable speed Geared Transmission through timer belt system.
- c) Microprocessor: 16 bit – Intelligent door
- d) Automatic Lock: Bi-stable Electromechanical for Safety and security.
- e) Safety stop / Reverse
- f) Automatic compensation of friction
- g) Adjustment of all basic parameters via integrated display push button.
- h) Anodised Aluminium Header frame.
- i) Anodised Aluminium hinged operator cover
- j) 2 trolleys per sliding leaf
- k) Insulated and modular Track Rail, track profile separate from Main profile
- l) UVV (Accident Prevention) and VDE (Electrical engineering)
- m) Sleek 190mm x 100mm REX dimension of header frame.
- n) 2 year warranty on operator sliding system.
- o) 5 position programme selective switch.

3. PERFORMANCE

a) Opening speed (Incremental setting)	:	1.2m/s
b) Closing speed (Incremental setting)	:	1.2m/s
c) Maximum Opening and Closing force	:	150 N.
d) Hold open time	:	0-180 S
e) Independent Adjustment of Speed and Force	:	Yes.

4. ELECTRICAL FEATURES

a) Standard power supply	:	230V, 50-60 Hz
b) type of motors	:	DC motor
c) Direct Drive Transmission	:	Geared Transmission
d) Power consumption during operation	:	250W
e) Ambient temperature during operation	:	-20 to 50 deg. celsius.

5. SAFETY

a) Safety Stop / Reverse	:	Yes – Adjustable
b) Infrared barriers	:	1 SET
c) Glass	:	12mm toughened frameless

6. REPLACEMENT OF GLASS BEFORE HANDING OVER

In case of glass breakage after installation, the glass will have to be replaced by deglazing the glass at site & the re-glazing of the new glass will have to be done at site without any extra cost.

FIDS

Technical Specifications

1. FLIGHT INFORMATION DISPLAY SYSTEM (FIDS)

A. GENERAL

1. The offered equipment by the bidder shall be compact, fully solid state, highly reliable and shall use latest state of the art technology.
2. The design and selection of the offered equipment by the bidder shall be consistent with the requirements of long-term trouble-free operation with highest degree of reliability and maintainability.
3. All offered equipment by the bidder shall be manufactured to continuously operate safely without undue heating, vibration, wear, corrosion, electromagnetic interference or any similar problems.
4. The offered equipment by the bidder shall be designed for continuous operation (24-hours a day and 365-days a year). The design life of the equipment shall be a minimum of SIX YEARS.
5. This life shall be achievable through normal and regular maintenance.
6. All types of spares and spare modules of the offered equipment for the FIDS shall be readily available with the bidder during life-time of the equipment, for maintenance, repairs and up keep of the equipment during warranty & CAMC period.
7. The Bidder shall undertake and ensure implementation of its offered solution and shall keep its in view the safety and protection of personnel, during normal operation and maintenance or during malfunctioning of any equipment or its sub-component. This shall be ensured as an integrated feature of design, manufacture and installation of offered equipment by bidder.
8. The bidder shall ensure adequate protection to be included for ensuring safety of personnel from any possible hazards, including EMI radiation, high voltages, etc.
9. The bidder shall furnish the details of EMI and Safety Standards met by his equipment and built-in safety features.
10. The offered equipment shall be constructed on a modular basis, using plug-in type units and components to the extent possible. Parts subject to failure, wear, corrosion or other deteriorations or requiring occasional inspection, adjustment or replacement shall be made accessible and capable of convenient inspection and removal.
11. Input and output termination cables in offered equipment shall be properly labelled to permit ready identification of the incoming/outgoing wiring.

12. All interconnecting cables in offered equipment shall also be appropriately labelled to facilitate convenient interconnection and minimize chances of incorrect connection.
13. All connecting cables required to inter-connect the equipment shall be supplied by the bidder as a part of the offered system. All cables shall be fully assembled, connector pre-terminated and factory tested at the time of supply as part of overall system check.

14. **LICENSES**

All Hardware system/component and Software supplied by bidder shall be licensed, as applicable, in favour of Airports Authority of India and valid for lifetime of the offered system.

15. **MAINS POWER SUPPLY**

- 15.1 Complete offered equipment shall operate with an un-interrupted AC power 230 Volts ($\pm 10\%$) single phase 50 Hz $\pm 5\%$. Reliable over & under voltage and over current protection circuits shall be provided in the power supply units of offered solution. The power supply units in complete offered solution shall be self-protecting, and shall protect connected equipment against conducted interference, noise, voltage dips and surges & impulses.
- 15.2 Mains Power Supplies used in offered solution/equipment shall be rugged enough to withstand variation in mains voltage and frequency over a long period of time so that the failures in the equipment due to power supply are minimized.

16. **INSTALLATION STANDARDS**

- 16.1 Installation shall be carried out by technically well qualified and certified personnel as per the requirements.
- 16.2 Contractors shall not outsource any part of the contract to any other vendor/third party contractor without prior permission of AAI.
- 16.3 Liability, if anything, arising out of such third-party contracts to any other vendor by contractor shall be to the contractor's account.
- 16.4 AAI shall not be liable on behalf of contractor to any other third party contractor/ Government of India/State/Regulatory Authorities.

- 16.5** Any liabilities arising out of such third party contracts by contractor or its men working at site shall be only to contractor's account and shall be deducted out of its running bills.
- 16.6** Contractor shall submit Police Verification Certificates and obtain necessary Airport Entry Permits, for allowing its men to work at AAI restricted premises.

17. QUALITY ASSURANCE STANDARDS

The contractor shall use Quality Assurance procedure compliant with Quality Assurance in system design, development, manufacturing, and installation and servicing- ISO 9001 Quality Management and Assurance Standards Part 3 – ISO 9001 Application and Development, Supply and Maintenance of software.

18. RELIABILITY

To ensure high availability and high reliability, the offered equipment design by the bidder and its OEM partner shall employ the most suitable engineering techniques, materials and dependable components, field proven design and rigorous inspection during manufacturing to ensure a very high MTBO (Mean Time between Outage) and MTBF (Mean Time between Failure) of equipment.

19. ENVIRONMENTAL CONDITIONS

The offered equipment shall be capable of maintaining its guaranteed performance when operating continuously for 24 hours a day and 365 days a year without any deviation in quality or degradation of system performance and all the parameter detailed in these specifications shall be guaranteed over the following environmental conditions:

i) Indoor Equipment:

Operating Temperature: 0 degree to + 40 degree Centigrade.

Relative Humidity: 80% up to 35 degree centigrade.

ii) Outdoor Equipment:

Operating Temperature: -10 degree to + 50 degree Centigrade.

Relative Humidity: 90% up to 35 degree centigrade

iii) Storage Temperature: -10 to + 70 degree Centigrade

B. SCOPE OF WORK

- Scope of work is briefly but not exhaustively described in succeeding paragraphs. The bidder has to quote considering the following scope of work to meet general, qualitative and technical requirements of tender as per this Section and mentioned in design criteria.
- The bidder firm shall provide the following system at specified Airport.

S. No.	System	Requirement
1	Flight Information Display System (FIDS)	Design, Supply, Installation, Testing and commissioning of Flight Information Display System for complete terminal building.

- **The scope of Flight Information Display System comprises of:**
 1. Design and Supply of all required hardware such as Display Monitors, Video walls and LED Boards with controller, Servers, Data Entry Terminal, Network equipment, Equipment Rack, KVM Switch, UPS, Data & Power cabling etc. and all required software such as Application, Antivirus, AFAS etc. including their upgrades, their installation, testing & commissioning
 2. The upgrades for the supplied Application, Antivirus, Control and Management Software and firmware shall be supplied and installed by the Bidder and without any legal implication to AAI, during the complete period of contract i.e. guarantee/ warranty and defects liability period and comprehensive AMC period. Report of upgradation of software at site shall be submitted to Engineer in Charge periodically (every six months), failing which, necessary deduction, as finalised by Engineer in Charge, shall be done and it will be binding on firm.
 3. The required communication media (Fibre Optic and other cables) including their lengths and interface equipment shall be determined based on the locations of the different type of equipment (display, switches, client terminal etc.) and shall be supplied by the bidder firm. Requisite terminations and integration of FO cables with the main system shall be done by the bidder firm.

4. The supply and laying of various types of cables shall be made after the survey of the routes and ascertaining of the exact cable length (s) requirements at site.
5. The laying of the outdoor cables shall be in accordance with the standard industry practice.
6. The offered system shall be complete with all equipment and accessories including connectors, patch cords, other networking accessories, mounting, and fixing hardware, plugs, sockets, etc.
7. Supply and fixing of Adaptors, Connectors, Patch Cords, Mounting/ Fixing hardware, Electrical Switches/ Sockets inside the racks and other accessories required for completion of work is deemed to be included in the scope of Bidder firm. This also includes cable channel/ Tray to be installed by the bidder firm within Equipment Room/ Control room as per requirement.
8. Testing of system components shall be done as per original equipment manufacturers specifications and guidelines.
9. The entire work has to be executed with total responsibility by bidder firm. All necessary technical completeness shall be ensured by the bidder firm at the time of quoting/ completion of works.
10. Bidder shall be responsible to conduct Site Acceptance Test (SAT), and to supply detailed documentation including as-built drawing in hard, soft copy at the Airport.
11. The bidder firm may undertake survey at specified airport at its own cost to understand the scope and intricacies involved in carrying out the work as per scope of tender.

C. GENERAL & QUALITATIVE REQUIREMENTS

- i) The bidder has to fill **General & Qualitative** compliance statement in the table given below:
- ii) For stating **compliance**: Write “**C**” in the third column below.

S. No.	Description	Statement of compliance
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(1)	(2)	(3)
	FLIGHT INFORMATION DISPLAY SYSTEM	
1.	GENERAL REQUIREMENTS	
1.1	The offered equipment by the bidder shall be compact, fully solid state, highly reliable and shall use latest state of the art technology.	
1.2	The offered equipment by the bidder shall be designed for continuous operation (24-hours a day and 365-days a year). The design life of the equipment shall be a minimum of SIX YEARS. This life shall be achievable through normal and regular maintenance during the period of Warranty and Comprehensive AMC.	
1.3	All offered equipment by the bidder shall be manufactured to continuously operate safely without undue heating, vibration, wear, corrosion, electromagnetic interference or any similar problems	
1.4	<p>Equipment with better specifications shall be accepted.</p> <p>Note: - Original Equipment Manufacturer (OEM) of Servers-FIDS, Server-AFAS, Server-NTP, Switches, Workstations, LED Display Monitors, LED Display Boards, UPS, etc. shall be ISO firms & the offered products must be certified for Safety/Emission of standards such as BIS/CE/EN/UL etc.</p> <p>All types of spares and spare modules of the offered equipment for the FIDS shall be readily available with the bidder and its OEM partner during life time of the equipment for maintenance, repairs and up keep of the equipment during warranty and post-warranty Annual Maintenance Contract.</p>	
1.5	The bidder shall undertake and ensure successful implementation of the offered solution, keeping in view the safety and protection of personnel during normal operation and maintenance or during malfunctioning of any equipment or its sub component. This shall be ensured as an integrated feature of design,	

	manufacture and installation by the offered equipment bidder.	
1.6	The bidder shall ensure that offered equipment has adequate protection to be included for ensuring safety of personnel from any possible hazards, including EMI radiation, high voltages, etc.	
1.7	The offered equipment shall be constructed on a modular basis, using plug-in type units and components to the extent possible. Parts subject to failure, wear, corrosion or other deteriorations or requiring occasional inspection, adjustment or replacement shall be made accessible and capable of convenient inspection and removal.	
1.8	Input/output termination cables in offered equipment shall be properly labelled to permit ready identification of the incoming/outgoing wiring.	
1.9	All interconnecting cables in offered equipment shall also be appropriately labelled to facilitate convenient interconnection and minimize chances of incorrect connection.	
1.10	All cables required to interconnect the equipment shall be supplied by the bidder as a part of solution.	
1.11	All cables shall be fully assembled, connector pre-terminated and factory tested at the time of supply as part of overall system check.	
1.12	Licenses: All Hardware and Software component supplied by bidder shall be licensed in favour of Airports Authority of India and valid for the lifetime of FIDS.	
2.	QUALITATIVE REQUIREMENTS	
2.1	The Flight Information Display System (FIDS) shall be installed at Airports for display of Passenger Information, Flight Information, Baggage Belt Information, Check In-Counter/Boarding Gate Information, Multimedia Advertisement, Weather Information, etc.	
2.2	The Flight Information Display System (FIDS) shall primarily consist of following sub-systems:	

i.	Flight Information Display System – To provide visual display of Airport's Flight Schedule & Status, Gate, Baggage Belt information, etc. on LED Display Board, 43"/55"/65"/85" LED Display Monitor, etc. through FIDS Application Software and Database on Hot/Standby Servers and Data Entry Application on Client Workstation, Administrative Application for Control and Monitoring of various devices, Page Design Application on Server/Workstation, etc.	
ii.	Automatic Flight Announcement System (AFAS) – To provide & integration with Airport Public Address System for Zonal Announcements of information, through Automatic Flight Announcement Software module and necessary hardware interfaces.	
2.3	System architecture shall be open for future expansion. AAI should be able to integrate additional standard LED/TFT Displays and Client terminals with the FIDS Server to access, control and display the flight information without need of any extra licenses, OEM approvals, etc.	
2.4	The FIDS Software, drivers & modules shall support minimum up to 128 displays locations, 16 Data Entry Terminals, 12 zones announcement, 32 clustered displays, 08 Monitoring & Administrative terminals, third party OEM FIDS software, 03 make OEM displays i.e. FIDS shall be scalable and expandable pre-wired (hardware & software) to add standard client PC/Laptop and Standard Display Monitors to expand the system as and when desired by AAI.	
2.5	Weather Interface allows the airport to display weather information for the different destinations providing an additional service for the passengers.	
3.	SYSTEM HARDWARE CONFIGURATION	
3.1	Servers, Display Monitors, Switch/routers and other components shall be of high end Common Off-the-Shelf (COTS) hardware .	
3.2	Re-engineered COTS hardware shall not be permitted/accepted. If such goods are found to be supplied at any stage, then it shall be the supplier's	

	responsibility to provide appropriate replacement without any additional cost to AAI.	
3.3	FID System shall be provided with two servers configured to operate in Automatic Failover configuration without any need of any manual intervention. During change over there shall be no loss of database transaction.	
3.4	After change-over except for administrator user, other users need not to know which server is in use or connect to get requisite functions/ functionalities.	
3.5	System shall provide audio-visual alarm for Error, Failure and Changeover of FIDS main or standby server, to system administrator or a designated client terminal automatically.	
3.6	After restoration of faulty server, recovery assistant/agent shall recover the data back in to the faulty server, restart all application/ modules and keep itself ready for automatic and manual hot change over function.	
3.7	System shall allow manual & automatic change over from main server to the standby server and vice versa.	
3.8	System shall have facility to recover inconsistent system/FIDS database from the other healthy & active server.	
3.9	FIDS shall be provided with client-server architecture with latest version of UNIX or LINUX or Microsoft Window Server as operating system of Server/Cluster server, and Windows or Linux as operating system of client terminals.	
3.10	Hardware Keys, dongles, Terminators, converters, interface conversion, connector, power cables, etc. shall be provided with the system as per the system requirement. Details of all such devices used for the FID System shall be provided to AAI.	
4.0	a. Monitor Size – 43” to 55 “with minimum 1” High Character (font) at; <ol style="list-style-type: none"> 1. Each Check-in Counters 2. Each Boarding Gates 3. Each Baggage Belts 4. VIP / CIP Lounges 	

	<p>b. Monitor Size – 43” to 55 “or Ultra Stretch Bar Type – 86” with minimum 1” High Character (font) at;</p> <ul style="list-style-type: none"> 1. Immigration 2. Custom Counters <p>c. Monitor Size – 55” to 85 “with minimum 1” High Character (font) at;</p> <ul style="list-style-type: none"> 1. Departure Hall 2. Check-in Hall 3. Arrival Hall 4. Baggage Claim Area 5. After Security Check <p>d. Monitor Size – 32” to 43 “with minimum 1” High Character (font) at;</p> <ul style="list-style-type: none"> 1. Baggage Make-up /Break-up Area 2. Terminal Manager 3. APD 4. MI Room <p>e. Monitor Size – 100” or Active LED Board (6X3 Meter, 3x2 Meter, 1.5x1Meter) with minimum 1” High Character (font) at;</p> <ul style="list-style-type: none"> 1. City Side - Outdoor Arrival /Departure <p>f. All Monitors, LED Boards, Video Walls shall be installed on the walls or SS pole/Frame, as per site condition.</p>	
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2. **SYSTEM DESIGN & TECHNICAL REQUIREMENTS**

GENERAL GUIDELINES

1. **“TECHNICAL SPECIFICATION” OF EACH ITEM SHALL BE THE PRIMARY CRITERIA FOR TECHNICAL EVALUATION** HOWEVER, BIDDER HAS TO ENDORSE AGAINST ALL “TECHNICAL FEATURES” OF SYSTEM AND EQUIPMENT MARKING AS “COMPLIANCE” AS A TOKEN OF CONFIRMATION OF FEATURES OFFERED.
2. THE SPECIFICATIONS DETAILED HEREUNDER ARE THE MINIMUM REQUIREMENTS. BIDDERS MAY OFFER SYSTEM/ EQUIPMENT/ ACCESSORIES/ SOFTWARE/ NETWORK EQUIPMENT/ CABLING OF BETTER SPECIFICATIONS.
3. THE BIDDER HAS TO FILL “TECHNICAL COMPLIANCE ALONG WITH FEATURES STATEMENT” AS PER DIRECTION GIVEN BELOW:
 - i) FOR STATING **COMPLIANCE**: WRITE “**C**” IN THE THIRD COLUMN OF STATEMENT.
 - ii) AGAINST EACH COMPLIANCE STATEMENT, WRITE SPECIFIC PARA AND PAGE OF SUPPORTING TECHNICAL DOCUMENTATION (FROM WHICH THE STATED COMPLIANCE COULD BE VERIFIED IN FOURTH COLUMN OF STATEMENT).
 - iii) **SPECIFICATIONS OF THE EQUIPMENT BETTER THAN THOSE MENTIONED IN “TECHNICAL REQUIREMENTS ALONG WITH FEATURES” SHALL BE ACCEPTED.**

1. **TECHNICAL SPECIFICATIONS / PARAMETERS FOR FIDS EQUIPMENTS**

Sl. NO.	Description	Statement of Compliance	Reference page & para no. of supporting document (Write N/A, if Not Applicable)
(1)	(2)	(3)	(4)

I.	FLIGHT INFORMATION DISPLAY SYSTEM		
1.	DISPLAY DEVICES		
1.1	GENERAL FEATURES:		
i.	System shall be capable of supporting various display devices including but not limited to TFT, LCD, LED Display Board, Intelligent Monitor, etc.		
ii.	Display clustering: System shall be capable of installing grid of multiple displays for spreading one page of information on multiple displays. The grid composition shall be user configurable.		
iii.	Devices shall be capable of displaying the information in Portrait and Landscape mode. This shall be user configurable.		
iv.	The display client software shall be able to handle various graphic formats including MPEG 2/4, MP4, JPEG, video clips, etc.		
v.	The displays shall have LED's to indicate operational status and network connectivity for easy maintenance.		
vi.	All the displays shall have IR Remote, controlling basic display functions such as Brightness, Contrast, Colour Control, etc.		
vii.	The display shall not have any controls within the reach of the public/or such controls shall be suitably covered to avoid possible tampering.		
viii.	Display controller shall be capable of remote monitoring of the displayed content/information from the central server & any work station in the network.		
ix.	It shall be possible to reset, restart and reboot the intelligent controller & display monitor remotely on the network.		
x.	It shall be possible to put the display in standby mode (soft power off) from the remote (network: server/workstation) or shall have a remote control to switch the display on or off in a go.		
xi.	Display monitor shall be provided with cabinet suitable for industrial/professional 24x7 use with arrangement for Wall and		

	Ceiling Mount installation or on SS Poles from ground with provision for Swivel movement.		
xii.	Display Monitor cabinet shall be designed for uniform heat dissipation/removal and shall have mechanism to remove heat from the cabinet. Heat removal mechanism shall automatically start functioning when temperatures reach certain threshold levels.		
xiii.	Suitable wall/ceiling/pedestal mounting shall be provided for Display Monitors in single or clustered configuration.		
2.	FIDS APPLICATION SOFTWARE		
	TECHNICAL FEATURES:		
2.1	GENERAL FEATURES		
a)	Application software shall meet requirements specified in this tender document. Software shall be supplied with license for the complete site without having any consideration for the number of clients, display, etc.		
b)	FIDS application shall include appropriate tools and interfaces for control, configuration, administration and maintenance of FIDS server and FIDS Database.		
c)	FIDS software shall have Standard Graphic User Interface for all modules and shall be fully menu driven. All software tools, configuration windows shall be windows based and menu driven.		
d)	The FIDS software shall be an open application using industry standard interfaces/protocols.		
e)	The FIDS software shall be able to handle proprietary as well as standard interface protocols.		
f)	FIDS Application Software shall have HTML/. devices.		
g)	Necessary Software tools shall be provided by the bidder for System Administration, Maintenance, Monitoring and User/Client		

	Operations, which shall monitor all connected devices and report status of the systems and all display devices.		
h)	Grouping of Display Devices in different areas of the terminal building shall be possible. The system administrator shall configure these groups. Assignment of relevant flight data to be displayed on different groups shall be possible.		
i)	The updated flight information shall be displayed on field display devices (Display Boards, Monitors, etc.) in real time.		
j)	The FIDS displays shall access the flight information database using standard web browsers (such as internet explorer, Firefox, safari, etc.).		
k)	In case of network outage, the client shall show the last updated information for a configurable period of time. Thereafter, display shall display a predefined page selected by user.		
2.2	RDBMS AND FIDS DATABASE		
a)	The FIDS Application Software shall be designed to work with industry standard RDBMS System like MS SQL, Oracle, MySQL, etc. The FIDS Application Software and the RDBMS shall be installed on the FIDS Servers.		
b)	The RDBMS shall be supplied with necessary number of client access license.		
c)	The Flight Information Database shall be maintained on the Main/Hot standby servers.		
d)	FIDS shall comply to push and pull data with AODB on XML/HTML; SITA/ARINC PREFANS/FANS ACARS based network, ICAO AFTN network, CUTE system, BHS and NTP Server for time synchronization		
e)	FIDS RDBMS shall maintain lookup tables for Airlines/Airports as per standard IATA Codes.		
f)	Transaction Log Tables and Archived Transaction Log shall be maintained on RDBMS Server for all transactions. The		

	Transaction Log Tables records shall be moved to Achieved Log Tables based on administrator configurable time parameters.		
g)	RDBMS shall implement record level locking, to enable updating of a flight record from only one Server or a Workstation at a time. Suitable WAIT message shall be displayed to other users trying to access the same record.		
2.3	The database architecture shall be based on the following standards:		
a)	The flight schedule shall be stored in a seasonal flight table where every flight record contains the flight frequency, validity period, etc.		
b)	Each record shall be presented in ICAO and IATA standard Airport/Airline/Flight Number codes and formats.		
c)	Each record shall handle not less than eight exceptions on the schedule, e.g., for public holidays.		
d)	A flight record shall handle at least four VIAs.		
e)	A flight record shall handle at least six code share flight numbers.		
f)	The seasonal flight schedule shall be expanded into an actual flight table where every flight is one record. The time window for the expansion shall be configurable.		
g)	Actual flights which are operated shall be stored in an archive table for statistics and reports. The record shall be deleted from the actual flight table according to configurable time parameters.		
h)	The flight records in the actual and archive flight table shall have a departure and arrival log; a join to a rotation between the arrival and departure log shall be possible.		
i)	The flights origin, destination, VIAs, airline, codes shares, etc. shall be represented by the appropriate ICAO and IATA codes to be linked to lookup tables.		
j)	All flights shall be distinct by flight nature according to IATA flight nature. The flight		

	nature shall be stored in a lookup table and linked by the nature code to the flight record.		
k)	The flight record shall be expandable to any field required by the airport. Information about the flight shall come from interfaces not limited to SITA, TEXT, AFTN, Flight Schedule, AODB and Docking System as made available at airport.		
l)	The design of FIDS Database and Application Software shall enable the user to retrieve reports and statistics for historical and actual flights.		
2.4	Administrative terminals, Client Terminals and Data entry terminals shall access the database using standard web browsers (such as internet explorer, Firefox, safari, etc.) for functions/ processes:		
a)	Updating the flight information database; I. Accessing the flight information database; II. Configuration and administration of the FID System, Database;		
b)	Bidder shall supply all necessary protocols (ICDs - Interconnect Control Documents), details of database structures with detailed inter-dependencies, communication protocols of the system at site to enable integration of FIDS in future with various other third party automation technologies.		
c)	The FIDS RDBMS shall maintain a MASTER FLIGHT TABLE (MFT) based on defined periodicity.		
d)	ACTUAL FLIGHT TABLE (AFT): From the flight database, the system shall automatically generate Actual Flight Table containing flights in chronological order for a user defined time interval (time interval in multiple of Hours shall be configurable/predefined by user). The AFT shall be generated automatically by the system on continuous bases. Updating of the AFT shall also be on continuous basis.		

	The left over flights of the previous intervals (configurable) and their status shall not be changed and shall be added on top of the new AFT automatically.		
e)	Each flight in the actual flight table shall have a traffic type flag not limited to the following		
	i. Operational		
	ii. Cancelled		
	iii. Diverted		
	iv. Re-routed		
	v. Non-operational.		
	vi. Suspended		
	vii. Planning		
f)	The current flights in the AFT shall be displayed on the display devices automatically as per the configuration of the display (by the operator through Software) without any manual intervention of the operator.		
g)	It shall be possible to manually update any data field of the Flight Information Data for all the flights in the AFT for the current day by the operator, and then transmit for displaying on the configured display devices.		
h)	System shall permit insertion and deletion of the flights from the AFT. System shall allow editing the database and updating the same from client terminal with appropriate access authorizations.		
i)	EDITING FLIGHT FOR A DAY: FIDS shall be provided with Software Tool to query the Database for a list of flights for any specific day of the week for editing. Operator shall have appropriate software interface for editing and modification of these flights.		
j)	Data entry on user forms/pages shall be validated for possible logical errors and accordingly pop-up shall be presented to user indicating warning along with the help		

	options.		
2.5	DISPLAY CONFIGURATION TOOL		
a)	It shall be possible to schedule such designed templates to the display devices based on programmed template and timed sequence.		
b)	All the parameters in the display configuration tools shall be user configurable.		
c)	Provision shall be available to configure number of displays into groups to display same set of information's.		
d)	The Display Configuration tool shall be primarily used to define the entire Video display network in terms of groups. The display shall be grouped on the bases of area (such as arrival, departure, etc.), flight types (domestic, international, etc.), flight operation (arriving, departing flight, etc.), language, gate type, baggage display, check in counter, etc. Once groups are made, each group will display the same set of messages in a synchronized manner.		
e)	For example, the Arrival Hall may be required to be split into two groups, namely those that display arrival messages in English and those that display arrival messages in Hindi. Once this is done using the Display Configuration Editor, these display monitors will automatically display arrival messages as per configured language option.		
2.6	INDIAN LANGUAGE DICTIONARY		
a)	The Indian Language Dictionary shall be created and maintained for all flight information fields.		
b)	The Dictionary shall be accessed during flight information display to provide automatic translation from English to Hindi and one local Indian language as per site requirement so that Flight Information entered in English by the operator is automatically translated into Hindi and any		

	other Indian language script, by the use of this dictionary.		
c)	The dictionary shall be editable and it shall have feature for addition and/or deletion of more words of Hindi and Local Indian Language.		
2.7	BAGGAGE CLAIM SOFTWARE MODULE		
	FIDS software shall have Baggage Claim module, with the following features:		
a)	Assignment of Baggage Belt Number to a flight.		
b)	On changing of flight status to "ARRIVED", the assigned Baggage Claim information shall be displayed on the respective Baggage Claim Display Monitor and Directory Display Monitor.		
c)	The data entry from Client Workstation for First Bag and Last Bag shall be processed with timestamp, updated in database and displayed on Baggage Claim Display Monitor.		
d)	Directory listing of baggage claim facility information shall be available for Directory Display Monitor.		
e)	FIDS shall have provision for interfacing with other automatic baggage handling system for updating FID database of the system.		
f)	The Baggage Claim Software Module shall be operated from Client Workstation by authorized user.		
2.8	BOARDING GATE DISPLAY MODULE		
	FIDS software shall have Boarding Gate Display Module with following features:		
a)	Assignment of Gate Number to a Boarding Flight		
b)	Next Flight Number to be displayed for Boarding		
c)	Boarding information shall be possible through CUTE System		
d)	The Boarding Gate Display Module shall be operated from Client Workstation by		

	authorized user.		
2.9	PAGE/TEMPLATE DESIGN TOOL		
a)	Page/Template Design Tool shall be provided for designing Screen Layout for display devices by choosing position of data (Header, Footer, Flight records, Airline Logo, Time of the Day, Free-form messages, Ticker/Scroll messages with flight data, etc.), fonts, text attributes (Regular, Bold, Italics), colour (Foreground, Background), background image, scrolling (direction, speed), etc.		
b)	Page design tool shall be a standard OEM product using GUI (Graphical User Interface).		
c)	Page design tool shall work from the FIDS server and client terminal connected to the FIDS network.		
d)	The access to this module shall be protected by passwords, and controlled by access level assigned by system administrator.		
e)	The design tool shall have easy to use Tool bars, Menus, Buttons, etc. and shall include Search for help on various functions/ capability of the system.		
f)	The page design tool shall have ability to manage graphics, true type fonts, video clips, and multimedia advertising. It shall permit use of animation and graphics for displaying flight information and free-form information pages.		
g)	It shall have provision to use different images of common graphic formats as backgrounds for screen templates.		
h)	The page design tool shall support selection and display of multiple language fonts.		
i)	Page design tool shall be provided with predefined screen layouts (template) with the system, and shall also have capability for designing new page templates. Any number of such custom-made screens shall be stored and displayed on a specified date and time.		

j)	Page design tool shall allow user to define page format and design each page combining fixed and dynamic information.		
k)	The software shall also permit creation of free-form pages wherein any special message or information of the general type can be entered for selective display on the intelligent display devices.		
l)	The Page Design Tool shall be user programmable. Display configuration shall be done to the extent of user to create and edit display script for one or many displays, display clocks, blank screens.		
m)	Only System administrator shall be allowed to publish newly designed pages.		
n)	It shall permit preview of any designed page.		
o)	The design tool shall allow the user to construct a display layout including graphics, true type fonts, video clips to a selection of flight data.		
p)	The tool shall have common features used in other design tools, like:		
	i. Horizontal, Vertical Grid alignment		
	ii. Snap to grid function		
	iii. Copy style function		
	iv. Different layers, bring to front, send to back, etc.		
	v. Tickers		
	vi. Page carousels.		
q)	Advanced table functions for summary displays		
	i. It shall be possible to place the Airline logo(s) (Image files in standard graphics format) on screen at User configurable/selectable specific positions using the page design tool.		
	ii. The system shall display free text information in a scrolling line at selectable position in the display devices (TFT- LCD/LED, etc.). This		

	feature shall be user selectable and user configurable.		
	iii. The module shall allow creating pages for displaying on TV using full screen and also in scalable window. The page shall be selectable in the aspect ratio of 4:3, 16:9, 21:9 and free form.		
2.10	SECURITY		
a.	Security		
	i. Multi-level password security shall be incorporated for addition, deletion, modification and update of the database for individual users. This shall be configurable by the user.		
	ii. Access to Server Operating System, Database and FIDS Application Software shall be restricted as per user authorization matrix, with access passwords.		
	iii. All the Systems shall be protected by individual user Ids and passwords.		
b.	The following access level shall be provided:		
	i. System administrator or System Manager: System-wide access to flight records and main schedule for all airlines.		
	ii. Users: Assigned with necessary access rights to create, modify, delete and add flight data for a specific airline or multiple airlines (as assigned) from a client work station		
c.	The system shall maintain transaction log for every event occurring in the system. A transaction shall be time and user stamped. The log file shall be maintained & archived for auditing.		
d.	The access rights to view, add, delete and update flight data shall be controlled on data field level.		
e.	Dedicated processes monitor the smooth operation of the system. Errors of individual		

	processes or any event in the system can be configured to generate a message to be stored in the system log files. The access to these log files is provided via the system console. Each system message to be stored in the log files can be individually copied.		
2.11	DEVICE MONITORING AND CONTROL		
a)	This module shall enable user to view status of displays/device connected to it and shall have access to the devices.		
b)	System shall monitor all the devices connected in the network and report status of system and display devices.		
c)	The modules shall be accessible from main system and also from remote PC connected to the FIDS network.		
d)	The access to this module shall be protected by passwords and controlled by access level assigned by system administrator.		
e)	Maintenance Utility shall be able to run from any PC/Client connected to the FIDS network.		
f)	The module shall remotely monitor health of each device connected in the system through SNMP and view online status of the display devices.		
g)	The module shall allow the user to remotely view the display content (i.e. currently displayed) of the LED/LCD display monitor.		
h)	Maintenance shall also enable to remotely view the content transmitted to the LED Line Display Board/LED Display Board.		
i)	Maintenance utility shall enable to remotely control display devices i.e. switch off, reboot, set device out of service, etc.		
j)	Licensed Remote Desktop Tool like Netviewer, Gotoassist, Logmein, Webex, Showmypc, shall be provided for remote access of Clients, Display Controllers, etc.		
2.12	REAL TIME CLOCK FOR DISPLAY DEVICES		

a)	The page design tool shall fix the clock to be shown in digital form at any selectable position on the screen. The clock shall have some of the attributes as for text items such as colour and size.		
b)	Clock's display shall be selectable for display and no display, as per user requirement.		
c)	The clock shall automatically get synchronized with the database server clock/NTP server. Software provision shall be made in the display controller to force automatic periodic synchronization, as well as manual synchronization as and when required by the user.		
2.13	AUTOMATIC FLIGHT ANNOUNCEMENT SYSTEM (AFAS) MODULE		
a)	AFAS		
i.	This software module shall scan the flight information database for valid announcements, construct announcements, convert announcement text into voice format/audio signals and send to the appropriate zone of the PA system for announcing. It shall translate the flight information in to voice format for automatic announcement on the existing PA system of the Airport.		
ii.	The system shall construct announcements, convert in to voice and send to the appropriate zone for announcing on the PA System.		
iii.	The system shall select zone of the PA system and send zone selection signals to the PA system for effecting the announcement in the selected zone.		
iv.	To construct voice for announcement, the system shall have the following technology:		
	A. Text-to-speech engine to automatically synthesize flight information into a voice for		

	announcement. The text to speech engine shall have:		
	a) The voice broadcast shall provision for male and female voice;		
	b) Different accents.		
	c) User shall have option to listen synthesized voice output		
	d) The above feature shall be user selectable.		
	OR B. Pre-recorded voice library for constructing announcements. Pre-recorded library shall include available list of 2048 airports, 2048 airlines, 4096 flight numbers and combination of existing flight route details up to 10240 in all three languages (Local, Hindi, and English) in male and female voices. The system shall allow updating of pre-recorded library and new voice file shall be added to the library.		
v.	This system shall translate flight information's into an audio file to be scheduled for announcement over Existing PA systems at the airport.		
vi.	The system shall be interfaced with the existing Public Address system. Audio output from this system shall be made available as input for the PA system.		
vii.	The System shall be built around proven technology such as IVR technology.		
viii.	The system shall build words and sentences from an in-built Voice Library as per match with the database.		
ix.	The system shall allow for creating new announcements and updating of Voice Library of pre-recorded announcements.		
x.	Multilingual announcement shall be possible i.e. Hindi, English and one of the		

	Indian Language as per the requirement of the airport		
xi.	The system shall provide for the following predefined announcements but not limited to:		
	a) Arrival, Arrival Delay, Arrival Cancellation		
	b) Departure, Departure Delay, Departure Cancellation.		
	c) Check In Call		
	d) Boarding Call, Final Call		
	e) Baggage in hall		
	f) General announcements.		
xii.	Operator shall have control over the following parameters but not limited to:		
	a) Voice generation Technology i.e. Text to speech engine or pre-recorded voice library.		
	b) Accent, male/female voice in text to speech engine		
	c) Time of announcement,		
	d) Time between announcements,		
	e) Frequency,		
	f) Repetition rate of announcement		
	g) Male/female voice in case of synthesized		
	h) There shall be a provision of fixed announcements to be repeated at regular intervals.		
	i) The System shall be able to select zones for announcement		
	j) The system shall permit to perform flight announcement manually by the operator/user.		
	k) Complete announcement script in all three languages (Local, Hindi, and English) shall be provided well in advance to AAI for approval, before recording.		

2.14	INTEGRATION WITH OTHER SYSTEMS		
	The system shall be capable of integrating with the other systems such as:		
	a) Airport Operational Database (AODB)		
	b) Departure Control System (DCS)		
	c) Baggage Handling System (BHS)		
	d) CUTE System		
	Integration with other technology/system involved in Airport operation shall be brought out by the supplier as per tender conditions.		
2.15	PUBLIC SUMMARY DISPLAYS		
a)	CODE SHARE HANDLING		
	i) The carrier (master) shall be displayed in first line. The carrier is displayed in one row and all code shared are displayed in rotation (alternatively) in a second row in alphabetic order.		
b)	FREE TEXT, PAGING		
	i) All public displays shall have a free text line for important information.		
	ii) The free text line shall be displayed on demand (selectable by user) in the last row of the public display.		
c)	DISPLAY CLUSTERING		
	i) If a display in a cluster of displays fails, the system shall detect the failure and migrate the data to the next display device. i.e. if the 2nd display in a cluster of 3 fails the more relevant information of the second display shall move to the 3rd display until the 2nd display is back to operation.		
	ii) A carousel e.g. between different languages and flight information pages shall be synchronized		

	iii) The cluster shall always display the same type of information.		
	iv) The flight which was previously displayed in the last row shall be displayed in the first row of the following display in a cluster of displays		
2.16			
A.	ARRIVAL SUMMARY		
	The display shall contain the following:		
	i) Airline logo		
	ii) Scheduled time of arrival		
	iii) Estimated time of arrival		
	iv) Flight number		
	v) Origin, via		
	vi) Remark *		
B.	DEPARTURE SUMMARY WITH GATE INFORMATION		
	The display shall display the following information:		
	i) Airline logo		
	ii) Scheduled time of departure		
	iii) Estimated time of departure		
	iv) Flight number		
	v) Destination, via		
	vi) Gate number		
C.	REMARKS FIELD SHALL DISPLAY FROM THE FOLLOWING		
i)	ARRIVAL FLIGHTS		
	a) On-time		
	b) Expected hh:mm		
	c) Delayed hh:mm		

	d) Landed hh:mm		
	e) Arrived hh:mm		
	e) Arrived hh:mm		
	g) Diverted		
ii)	DEPARTURE FLIGHTS		
	a) On-time;		
	b) Delayed hh:mm;		
	c) Departed hh:mm;		
	d) Cancelled;		
	e) Next Info hh:mm;		
	f) Gate Open;		
	g) Boarding;		
	h) Final Call;		
	i) Gate Closed;		
	D. LOCATION RELATED DISPLAYS (CHECK-IN COUNTER, BOARDING GATE, BELT)		
	a) The display shall show flight information only if the resource is active.		
	b) The operator shall be able to open the display on demand, if allocation time is exceeded due to delays. The operator shall be able to close the display at any time.		
	c) If a control device is used at location it shall be password protected. According to the allocation plan, only the current flight shall be displayed.		
	d) CHECK IN COUNTER DISPLAYS		
	i) The check-in counter display shall switch between common check-in, and dedicated check-in.		

	ii) In case the desk is allocated to more than one flight the display shall show information of all those flights allocated to the check in.		
	iii) The common check-in counter layout shall show airline or Ground Handler Logo, Class, and four free configurable Remarks.		
	iv) According to the allocation, the layout shall display the IATA Colour code.		
	v) The counter display shall show flight number and logo of the airline, as well as code share information, destination, Via, Passenger Class.		
	vi) Free text remark shall be made available as per the operator request.		
	e) BAGGAGE CLAIM AREA		
	i) The display will show up to 5 flights only if the flight is on blocks and allocated to the resource.		
	ii) Airline Logo, Airline, Code shares, Origin, Scheduled time of arrival, and First & Last Bag Time are to be displayed.		
	iii) The layout shall change automatically according to the number of flights to be displayed to achieve the maximum character size and legibility from distance.		
	iv) The flight shall disappear from the display after a configurable period of time or after the manual input "last bag" + 'x' minutes. The parameter 'x' shall be user configurable.		
	vi) BAGGAGE SUMMARY WITH BELT INFORMATION:		
	The display shall contain the following:		
	a) Belt number:		

	b) Airline logo		
	c) Origin, via		
	d) Flight Number		
2.14	CLIENT SYSTEM		
	FIDS Application Software and its component for access control and configuration of FIDS database as per the requirements specified in the tender.		
	The client application shall have standard web browser based/HTML interface to the FIDS server.		
	Touch Screen Client Application shall have design to utilize the touchscreen interface for easy data entry by on-screen keypads.		
	Any additional software plug in/ module, if required for access, control, configuration and administration of the FIDs, shall be supplied for use at an airport site irrespective of number of client/terminals at that site.		
3.	TRAINING & DOCUMENTATION		
	The bidder firm along with OEM partner firm shall provide following types of training as detailed below:		
3.1	MAINTENANCE AND SYSTEM ADMINISTRATIVE TRAINING		
	Maintenance and system administration training of minimum THREE trainees nominated by AAI, for FIVE working days at site. The training shall be designed and structured so that on successful completion of the training the participants shall be able to perform:		
	a. Basics of DBMS used.		
	b. System Administration of DBMS used.		
	c. Icon based and command line interface.		

	d. System setting up and Configuration of offered system from Scratch.		
	e. Adding, deleting, restricting of users to system		
	f. Adding of new displays, third party displays, user terminals & other components of the system		
	g. Interconnecting of system functional subcomponents		
	h. CCA/LRU replacement techniques		
	i. CCA/LRU level maintenance.		
	j. Preventive maintenance of the system		
	k. Basics of icon based or command line commands used		
	l. Configuration, optimization and alignment of the system with the help of the documents and software supplied along with the equipment/system.		
	m. Fault isolation up to Module/LRU level using diagnostic tools and general-purpose test equipment		
	n. Taking corrective action by replacing the faulty Module/LRU and restoring the equipment for normal operation,		
	o. Installation procedures for system hardware & software, configuration recovery, reloading of software drivers/modules of operating system and application software.		
	p. Performing full, differential, restricted backups and restoration to partitions as required.		
3.2	OPERATIONAL TRAINING		
	On the Job Operational Training shall be provided for THREE working days to one batch of SIX to EIGHT Trainees nominated by AAI from AAI, Airlines and other stake holders. The training shall be designed and structured so that on successful completion of the training the participants shall be able to perform:		

	a. Basics of icon-based commands used.		
	b. Understanding system is functional or not.		
	c. Basic fault/fault log monitoring.		
	d. Logging into the system.		
	e. Issue commands to display different shows.		
	f. Predicting restrictions of users to system.		
	g. Using of new displays, third party displays, user terminals & other components of the system		
	h. Using map depicting Interconnection of system fun		
	i. Call logging for Preventive maintenance.		
	j. Assisting System admin in Configuration, optimization and alignment of the system.		
	k. Assisting in Fault isolation up to Module/LRU level		
	l. Assisting in corrective action and restoring the equipment for normal operation,		
	m. Changing of different predetermined layouts, etc.		
	The bidder and OEM firm shall identify the prerequisite for the trainees for each of the training program. Complete training syllabus shall be submitted by the bidder in consultation with OEM to AAI before training.		
3.3	DOCUMENTATION		
	Two set each of soft copy and hard copy of Installation, Operations including theory of operation, Technical Manual, Maintenance manual; Troubleshooting of the system, procedure for loading of the system and application software, etc. shall be supplied		

	at site . The Operation, Technical and Maintenance manual will cover:-		
	a. General technical description and theory of operation		
	b. Block diagram description up to LRU level		
	c. Component level lay out diagram with signal flows		
	d. Preventive maintenance		
	e. Fault analysis and repair		
	f. Detail circuit diagrams/schematic diagrams		
	g. Part list & component list with part number		
	h. Installation procedures for software, configuration recovery, reloading of software drivers/modules of operating system and application software.		
	i. Technical & operational manuals		
	j. Schematic/signal flow/block diagrams		
	k. Maintenance manuals		
	l. Maintenance and System Administrative procedures.		
	m. Operational Training.		
	n. Technical documents required for maintenance and fault finding for each module of the offered equipment shall be provided.		
	o. Integration with other systems: To enable integration of offered system, interface control document for the systems shall be provided.		
3.4	MONITOR / LED LOCATIONS AND SIZE		

3.4. 1	Flight Information Display system (FIDS) Monitors locations at Airports.
	<p>g. Monitor Size – 43” to 55 “with minimum 1” High Character (font) at;</p> <ol style="list-style-type: none"> 1. Each Check-in Counters 2. Each Boarding Gates 3. Each Baggage Belts 4. VIP / CIP Lounges <p>h. Monitor Size – 43” to 55 “or Ultra Stretch Bar Type – 86” with minimum 1” High Character (font) at;</p> <ol style="list-style-type: none"> 1. Immigration 2. Custom Counters <p>i. Monitor Size – 55” to 85 “ with minimum 1” High Character (font) at;</p> <ol style="list-style-type: none"> 1. Departure Hall 2. Check-in Hall 3. Arrival Hall 4. Baggage Claim Area 5. After Security Check <p>j. Monitor Size – 32” to 43 “with minimum 1” High Character (font) at;</p> <ol style="list-style-type: none"> 1. Baggage Make-up /Break-up Area 2. Terminal Manager 3. APD 4. MI Room <p>k. Monitor Size – 100” or Active LED Board (6X3 Meter, 3x2 Meter, 1.5x1Meter) with minimum 1” High Character (font) at;</p> <ol style="list-style-type: none"> 1. City Side 2. Outdoor Arrival /Departure

	<u>Performance certificate for the past 2 Years from the end user is to be submitted with offered Monitors/LED Boards.</u>		
	EQUIPMENT SPECIFICATIONS.		
4.	FIDS SERVER		
	To work as Main & Standby (Set of 2 Servers)		
4.1	TECHNICAL SPECIFICATIONS:		
i.	CPU: 64-bit high performance, 12 Core or higher Intel/AMD CPU operating at 3GHz or more with 24 MB Cache or more		
ii.	Memory: 32 GB of DDR5 RAM or more/better expandable up to 64 GB		
iii.	Chassis: Rack Mount type		
iv.	SAS /SATA 10K rpm hot-swappable Hard Disk in RAID 5 or better configuration having usable space of 1 TB or more.		
v.	Hot Swappable redundant power supply.		
4.2	TECHNICAL FEATURES:		
i.	NIC - Dual Integrated 10/100/1000 Mbps ports.		
ii.	DVD- RW Drive		
iii.	USB Optical Mouse with scroll, Keyboard shared through KVM switch, USB 3.0 or higher Ports and other Ports as required		
iv.	Other PCB/Modules/hardware as per system requirements.		
v.	OS: UNIX/LINUX/Microsoft Windows Server licensed (Latest version).		
vi.	Licensed Antivirus with update subscription valid till warranty and AMC period.		
5.	AFAS SERVER		
5.1	TECHNICAL SPECIFICATIONS:		
i.	CPU: Intel i7/AMD or better CPU operating at 3 GHz or more with 12MB Cache or more		

ii.	RAM: 16GB or more		
iii.	10000 rpm Hard Disk having usable space of 1 TB or more		
iv.	To be mounted in rack.		
5.2	TECHNICAL FEATURES:		
i.	NIC – 2 Nos. of 10/100/1000 Mbps ports		
ii.	At least 2 x PCI express I/O slots, suitable slot for 3rd party cards as required.		
iii.	USB 3.0 or higher port: At least 4 USB ports (2 in the front).		
iv.	DVD RW Drive		
v.	OS: UNIX/LINUX/Microsoft Windows Licensed Operating System		
vi.	Licensed Antivirus client version valid for Warranty & AMC Period.		
vii.	In addition to the above, the Server for AFAS shall be equipped with: PA Interface: Professional Two Channel On-board Sound Card with Digital I/O for AFAS Application with Zone Selection facility for at least 8 Zones.		
6.	CLIENT TERMINAL		
	Client Terminals shall be used to access FIDS Application Software User Interface for viewing and updating the Flight Information Database.		
6.1	TECHNICAL SPECIFICATIONS:		
i.	CPU: Intel i7/AMD or better CPU operating at 2.4 GHz or more with 8MB Cache or more		
ii.	RAM: 8GB or more		
iii.	Motherboard Chipset: OEM Motherboard		

iv.	SAS/SATA 7200 rpm Hard Disk having usable space of 1TB or more		
6.2	TECHNICAL FEATURES:		
i.	NIC – Gigabit Ethernet port		
ii.	At least 2 x PCI express I/O slots		
iii.	USB 2.0 or higher port: At least 4 USB ports (2 in the front).		
iv.	DVD RW Drive		
v.	USB optical Mouse with scroll and Keyboard		
vi.	23"/21" LCD/LED or better monitor.		
vii.	OS: UNIX/LINUX/Windows Licensed, latest version		
viii.	Licensed Antivirus valid for client version for Warranty & AMC Period.		
ix.	Standard Computer table made of combination of steel/MS material along with top shelf of standard material & size from reputed manufacturer such as Godrej/ Durion etc. as approved by Engineer in charge shall be supplied by the contractor with each Workstation/Client Terminal at equipment room		
7.	DISPLAY DEVICES		
7.1	GENERAL FEATURES:		
i.	Devices shall be capable of displaying the information in Portrait and Landscape mode. This shall be user configurable.		
ii.	All the displays shall have IR Remote, controlling basic display functions such as Brightness, Contrast, Colour Control, etc.		
iii.	It shall be possible to put the display in standby mode (soft power off) from the remote (network: server/workstation) or		

	shall have a remote control to switch the display on or off in a go.		
iv.	Display monitor shall be provided with cabinet suitable for industrial/professional 24x7 use with arrangement for Wall and Ceiling Mount installation with provision for Swivel movement.		
v.	Suitable wall/ceiling/pedestal mounting of Stainless Steel (SS 304) shall be provided for Display Monitors in single or clustered configuration, the design of SS 304 mounting to be approved by Engineer in charge.		
7.2	FIDS LED DISPLAY BOARD		
	True Colour LED Display Board For Outdoor Installation		
7.2.1	TECHNICAL SPECIFICATIONS:		
i.	Display Area: For 3X2 m Board shall be 2.88mX1.92m Pixel Pitch: For 3x2 m2 Board: 6mm		
ii.	Pixel density: For 6mm pixel pitch it shall be 30000 dot/m ²		
iii.	Pixel Configuration: For 3X2 m2 Board shall be 1R,1G,1B		
iv.	LED make: Avago, Cree, Nischia, Osram [RoHS compliant and Lead (Pb) Free]		
v.	Brightness: $\geq 4000 \text{ cd/ m}^2$		
vi.	Contrast Ratio: 3000:1		
7.2.2	TECHNICAL FEATURES:		
i.	Optimal viewing distance: 10 – 50 MTRS.		

ii.	Optimal Viewing Angle: 100° (H), 40° (V)		
iii.	Grey Scale/Colours: 256/16 Million Colours		
iv.	Processing: 16 bit/color		
v.	Interface: TCP/IP LAN RJ45		
vi.	Weather Protection: IP65 (Front) IP54 (Rear)		
vii.	Ambient Light Sensor		
viii.	Max. Power Consumption: $\leq 1000\text{W/m}^2$		
ix.	Construction material: Stainless Steel Cabinet SS grade 304		
7.3	FIDS LED DISPLAY MONITORS		
i.	Technical Features:		
ii.	Each Display monitor shall consist of:		
iii.	Professional Grade LED Monitor		
iv.	Suitable for 24x7 operation		
v.	Inbuilt Pluggable Intelligent Controller within OEM cabinet of Monitor. No external/ attached controller will be accepted.		
7.3.1	Flight Information Display System (FIDS) LED DISPLAY MONITORS: 42"/43"/55"/65" and 75" .		
i.	TECHNICAL SPECIFICATIONS:		
ii.	Back Light: LED		
iii.	Aspect Ratio: 16:9		
iv.	Resolution: Full HD or better.		
v.	Brightness: 700 cd/m2 or better		
vi.	Dynamic Contrast Ratio: 4,50,000:1 or better		

vii.	Viewing angle: (Horizontal/vertical): 176° or more		
7.3.2	TECHNICAL FEATURES:		
i.	Ambient Light Sensor		
ii.	Video Input Ports:		
iii.	Digital Ports: HDMI or DVI-D; USB		
iv.	Front Glass with Anti-Glare and Hard coating		
v.	Display Monitor for outdoor installation: No external cabinet to be installed over composite monitor. It shall be OEM Cabinet and inherent part of Monitor & protect from dust, sunlight, etc.		
vi.	Certification: UL for safety, FCC for EMC and BIS.		
7.4	INTELLIGENT CONTROLLER (for 42/43/55/65/75" Displays)		
7.4.1	TECHNICAL SPECIFICATIONS:		
i.	Processor: Intel/AMD 1.5 GHz or better, FSB 400 MHz		
ii.	RAM: 16 GB or more		
iii.	Flash Hard Disk: 64 GB or more		
iv.	Keyboard and mouse connectivity		
v.	LAN/Network: Integrated 10/100/1000 Base T NIC with RJ 45 connector		
vi.	Wi-Fi connectivity supporting 802.11 a/b g/n		
7.4.2	TECHNICAL FEATURES:		
i.	USB 3.0/2.0 Port: 2 Nos.		
ii.	Graphic Card shall be having specifications to meet the requirement of supporting Display/Monitor.		
iii.	Software: Windows or Linux base Embedded Operating system and associated software as required.		

iv.	Display controller shall be capable of remote monitoring of the displayed content/information from the central server & any work station in the network.		
v.	It shall be possible to reset, restart and reboot the built-in intelligent controller & display monitor remotely on the network.		
8	NETWORK TIME PROTOCOL (NTP) SERVER		
8.1	TECHNICAL SPECIFICATIONS:		
i.	GPS/GLONASS satellite supported L1/L2/L5 Frequency band, Rack Mount Type, NTP SERVER to maintain and display IP based NTP time across the network containing L2/L3 switches shall be supplied by the bidder. NTP server shall act as a master clock with accuracy better than 50 ms in the network to which other clients shall interconnect over the network using NTP client software on Windows or Linux OS and synchronize periodically. It shall provide diagnostic and status ports/indications for automatic/manual intervention.		
ii.	The GPS NTP Server shall be equipped with two independent network interfaces (10/100/1000 Mbps Ports).		
8.2	TECHNICAL FEATURES:		
i.	NTP Server shall support all the required networking protocols.		
ii.	SNMP v3 support for status and configuration and SNMP Trap messages.		
iii.	The GPS NTP Server shall be supplied and configured by bidder, with a GPS Antenna/Converter Unit and standard RG58 coaxial cable, as per site requirement.		
9.	FID Control Kiosk for Departure/ Arrival /Security Hall		

9.1	<p>Manufacturer/OEM shall enclose copy of certification of ISO to ensure consistent product quality and meeting all regulatory norms.</p> <p>The console shall be built to withstand life span of at-least 10 years on normal use, wear and tear.</p>		
	<p>1. Kiosk shall have provision to accommodate upto one 21" to 23" touch screen, one metallic keyboard with track pad, Kiosk shall have sufficient space to accommodate the CPU, UPS & PDU (power distribution unit for powering all equipment with two spare 6A Power ports) and shall be accessible through rear door. The entire design shall be modular; consisting of interchangeable and replaceable parts. Touch/Non-Touch screen shall have separate door for the accessibility/maintenance and all locks shall feature 2-point locking arrangement. Design shall be extremely rugged to ensure a minimum life of 10 years for structural stability, moving and non-moving parts. The kiosk must be IP22 compliant to ensure rodent proof enclosure. Kiosk shall have PU wrist support for user comfort. Kiosk shall have feature of flush mounted metallic keyboard tray, in idle condition the tray shall remain flushed to the front fascia of the kiosk through "Child proof Clip Locking" and shall be accessed as and when required. Valid certificate to be submitted along with the bid.</p> <p>2. The structure shall be made up of minimum 2 mm thick heavy-duty vertical and horizontal profiles. These profiles shall be accurately inserted and welded over minimum 10 mm thick solid base.</p>		

	<p>Outer shell, including all hinged and non-hinged parts shall be made up of minimum 1.5 mm thick sheet.</p> <p>3. All the sheet metal parts must be finished with a durable anti-bacterial powder coating (with added silver ions) to reduce formation of bacterial colonies on the front surface.</p> <p>4. The Base shall have concealed provision of grouting to the floor with anchor fasteners.</p> <p>5. Touch/Non-Touch Screen shall be accessible from Rear doors with hinges. All doors to have Foam Gasket to protect the equipment from dust particles. Doors shall have 2-Point Lockable system and shall have common keys for hassle-free maintenance.</p> <p>6. Modularity is to ensure replaceability in an unlikely case of damage. The rigidity and strength must not be compromised despite the modular feature of structure.</p> <p>7. Light Leaks, sharp edges and corners shall be deemed un-acceptable. Front Edge of the keyboard shall have moulded polyurethane edge for ergonomic wrist support.</p> <p>8. OEM shall enclose copy of certification of ISO.</p> <p>9. Bare Enclosure shall be RoHS certified to ensure restriction of hazardous material.</p>		
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	<p>10. Manufacture shall have CE Compliance certificate.</p> <p>11. A typical diagram for FID Control Kiosk is attached at Fig 3 for reference.</p> <p>Final drawings and design will be approved by Engineer-In-charge/CHQ before the time of execution.</p>		
	19" FLOOR STANDING EQUIPMENT RACK (42/40/36 U)		
	TECHNICAL FEATURES:		
	Equipment rack (standard 19") fully wired for housing Central Switches, FIDS Servers, AFAS Server, NTP Server, KVM Switch with integrated 17" Monitor etc.		
	All the Servers shall be installed in 19" 42/40/36U Rack with OEM Rack Mounting Kit(s).		
	Wiring shall be neatly done with suitable cable manager.		
	Power supply wiring with suitable capacity sockets and proper Earthing shall be neatly installed.		
	Rack shall include all required parts/accessories to install all devices/equipment. It shall have front and rear glass/perforated cover with locks. Rack's depth shall be sufficient to install all Servers and other network components and the doors remain closed.		
	Rack shall be provided with rack-mounted Fan unit (2 or more Fans) for Air Circulation.		
	17" LCD MONITOR WITH INTEGRATED 12-PORT KVM SWITCH		
	TECHNICAL FEATURES:		

	Rack mountable Integrated KVM Switch shall be provided for connecting Keyboard, Video and Mouse interfaces of the Servers. KVM Switch shall be OEM integrated unit having 17" LCD/LED foldable Monitor, Keyboard & Mouse and a selection mechanism to allow connection to each Server/device connected to the KVM. The KVM switch shall be installed in the 19" Equipment Rack.		
	POWER REQUIREMENTS		
	10/20 KVA UPS IN REDUNDANT (1+1) CONFIGURATION		
	10/20 KVA Floor Mounted On-Line UPS 1+1 (Single/Three Phase AC Input & single Phase AC Output) with input/output Isolation Transformer (There shall be nothing common between input & output connections/leads) and Individual SMF Battery Bank to provide 30 minutes Battery back-up for each UPS, RS 232 Serial Port or RJ45 with Software for Computer Interface and Redundant Configuration.		
	UPS operation shall be configured in such a way that the failure of one UPS shall result in total load to be automatically transferred to other UPS of the cluster.		
	TECHNICAL SPECIFICATIONS:		
	General:		
	UPS shall be free from workmanship defects. The Equipment shall be complete with all parts and all parts shall be functional.		
	By-pass facility shall be provided for maintenance of UPS.		

	UPS shall supply output power and charging current at the same time.		
	Switching device shall be IGBT		
	Digital Signal Processors (DSP) shall be used for all monitoring and control electronics of UPS.		
	Switching frequency shall be above 10 KHz or better and shall be declared in the offer.		
	Input: 170V-280V Single phase /350V-450V, 50 Hz \pm 3% Three Phase AC		
	Output: 230V \pm 1% , 50 \pm 0.5Hz, Single phase. Voltage regulation from no load to full load shall be within \pm 1% in both the cases. UPS shall also have facility for operation in synchronous mode in which output frequency shall be same as that of mains frequency.		
	Total harmonics distortion at output: 3% maximum for UPS on resistive load, if total input harmonics are less than or equal to 10%.		
	Efficiency (at rated output voltage and frequency): Overall efficiency (minimum): 90%		
	UPS power factor at rated load: better than 0.8 lagging or better.		
	Over load: UPS shall withstand 20% overload for 1 minute and 50% over load for 30 seconds.		
	TECHNICAL FEATURES:		
	Protections: Following protection shall be provided in UPS:		
	Over voltage, short circuit, and overload at UPS output terminal.		

	Under voltage at battery terminal.		
	Overshoot and undershoot shall not be greater than 4% of rated voltage for duration of 40m sec. (maximum)		
	Indicators and meters:		
	Following indicators shall be provided:		
	Mains presence.		
	Battery charging and discharging		
	Output overload		
	Low battery voltage.		
	Digital Display shall be provided for indicating/monitoring the following parameters in UPS:		
	Input AC voltage.		
	Output AC Voltage, frequency		
	Battery voltage and current.		
	Battery bank:		
	UPS shall be supplied with SMF VRLA battery only.		
	Batteries for UPS shall be of the following makes: EXIDE, PANASONIC, AMAR RAJA, GLOBAL, ROCKET, BASE.		
	The UPS shall be complete with Trolley for battery bank and the firm shall also connect the batteries with UPS and commission the same.		
	Minimum AH rating of battery bank with suitable rack for the duration of back up time shall be as detailed below: UPS rating in KVA: 20KVA; Min. 30 minutes back up 10KVA; Min. 30 minutes back up		

	Testing requirement for UPS:		
	Type Tests: Following shall constitute type test and at least one sample shall be type tested for each rating with maximum backup time. Type testing shall be conducted at the premises of the manufacturer in presence of an officer deputed by AAI:		
	Visual examination.		
	Verification of output power, capacity test and frequency.		
	Verification of voltage regulation.		
	Verification of efficiency.		
	Verification of total harmonics distortion.		
	Verification of overshoot, undershoot limits and over voltage protection.		
	Verification for insulation resistance, leakage current high voltage. Insulation resistance should not be less than 100 mega ohms.		
	POWER DISTRIBUTION PANEL (PDP)		
	TECHNICAL FEATURES:		
	The power distribution panels shall be provided to meet the system requirement along with UPS. The power distribution panel shall provide MCBs with proper ratings for all equipment including field equipment like Network Switches, Cameras, Workstations, Displays etc. Sufficient number of Loops are required to be made to avoid high current passing in single loop – one MCB for each loop and one Mains Control Switch.		
	EARTHING		
	TECHNICAL FEATURES:		
	The system shall be configured to be grounded electrically to a common ground		

	point to prevent interference to the system from external and internal sources and to protect equipment and personnel.		
	Earthing of the System: The contractor firm shall provide the Earthing to each system separately by making the earth-pit as follows:		
	Supply and installation of the copper plate - 600x600x3mm		
	GI (galvanized) pipe of 40 mm diameter is to be used		
	The earth-pit to be dug for a depth of 3.75 mts.		
	Copper plate is to be properly fastened with nuts and bolts to the copper wire of size 14SWG. This copper strip/copper wire is laid up to the main distribution board of the centre.		
	The copper strip without GI pipe or thick copper wire with GI pipe should be laid up to the Server Room.		
	19 mm GI pipe to be laid for watering purposes. This will have a funnel at the top of the earth pit chamber.		
	Minimum 70 Kg. of salt and approx. 100 Kg. of coal are to be filled in the pit, in layers, after the plate and the pipes are laid in the pit.		
	Measurement the earth resistance at the pit should be less than 2 Ohms.		
	Standard Chemical Earthing may be provided instead of above-mentioned Conventional Earthing in case of the rocky soil at site and/or 2 ohms resistance is not achieved.		
	Contractor shall ensure proper grounding/Earthing of all system		

	equipment, cabinets and AC power supply outlet.		
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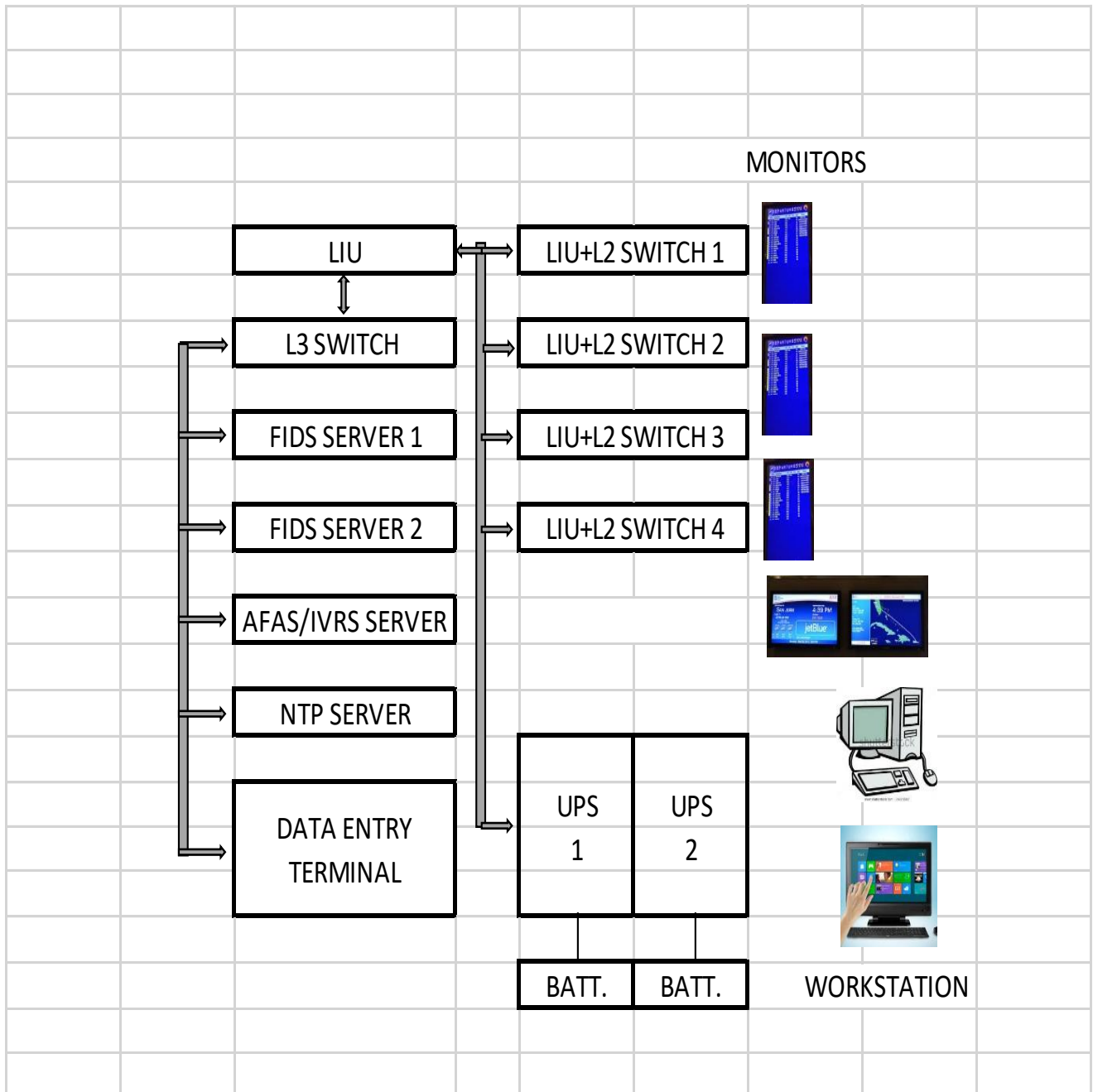
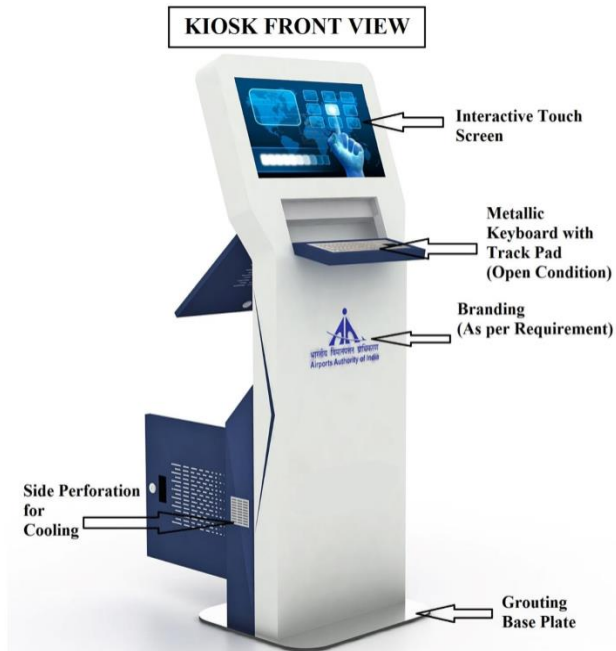
FLIGHT INFORMATION DISPLAY SYSTEM SCHEMATIC:

Fig 3: Typical diagram of FID Control Kiosk for Departure/Arrival/Security Hall

Front-side:



Rear View:



SCOPE AND FUNCTIONAL PARAMETERS OF SURVEILLANCE CCTV SYSTEM

SECTION- I

1. Guidelines:

- 1.1 IP SCCTV System shall be suitable for commercial supply of 230 V ($\pm 10\%$), 50 Hz.($\pm 5\%$) single phase AC and it shall be comprises of IP Digital Outdoor & Indoor Colour video Cameras, Network Switches, Network Video Recorder/ CAMERA SERVER. Storage system consisting of IP Network, Attached Storage for period of 30 days (NAS)/Storage Area Network (SAN) for recording, Application software with latest Surveillance Video Management System (SVMS), Colour LED/LCD monitor with LED back light, with workstation having Mouse-KeyBoard for viewing of live and recorded images online UPS power backup for minimum 30 minutes on full load and including with cabling and conduit work as required at site. System shall have provision of WAN connectivity for remote monitoring.
- 1.2 System shall facilitate viewing of live and recorded images and controlling of all cameras by the authorized users present in the LAN and WAN connectivity for remote monitoring through firewall.
- 1.3 System shall provide inter-operability of hardware, operating system, software, networking, printing, database connectivity, reporting, and communication protocols. System expansion shall be possible through off-the-shelf available hardware.
- 1.4 IP based SCCTV System shall use video signals from various types of indoor/outdoor CMOS colour cameras installed at different locations, process them for viewing, recording and replay simultaneously on all workstations/Video wall at Central Control Room/Local Control Rooms of all the cameras after video compression using H.265 or better standard. Joystick controller/ Mouse-KeyBoard shall be used for Pan, Tilt, Zoom, Camera Selection and other functions of desired cameras. When both the viewing stream and the recording stream are set at the same FPS and resolution, the camera shall send on the network a single multicast stream this shall help reduce network Bandwidth.
- 1.5 System must provide built-in facility of Water-marking & Digital Certificate AES 256 or better to ensure tamperproof recording so that these can be used as evidence at a later date. The recording shall support audit trail feature.
- 1.6 System to have facility of additional camera installation beyond the originally planned capacity for a minimum of 25% for hardware as well as VMS software expansion.

- 1.7 The offered system shall have facility to export the desired portion of clipping (from a desired date/time to another desired date/time) of multiple cameras on external storage Device. Viewing of this recording shall be possible on standard PC using standard software like Windows Media Player, though there should be an option available to export native recordings with OEM player. VMS Player should be able to play exported video in adaptive views and should be able to play up to 64 cameras.
- 1.8 VMS System should have built-in health diagnostic module to monitor details like Network link failure, device online/ offline details, Camera failure, Storage disconnection error, bandwidth loss errors etc. Further it shall be capable to monitor operation of all services and having facility to restart automatically when system malfunctions.
- 1.9 The system shall provide tamper-proof video recording.
- 1.10 **Retrieval:** The SCCTV software application should allow retrieval of data instantaneously or any date/time interval chosen through search functionality of the application software. In case data is older than 30 days and available, the retrieval should be possible. The system should also allow for backup of specific data on any external storage device or any other device in a format which can be replayed through a standard PC based software. Log of any such activity should be maintained by the system, which can be audited at a later date.
- 1.11 Capturing of Driver's Photographs & Vehicle Registration Number:
 - (a) It shall have the capability of capturing photographs of drivers at Naka points.
 - (b) The system shall be equipped with Automatic Number Plate Recognition (ANPR) of vehicles.
- 1.12 **Artificial Intelligence:** It shall have image tracking facility. If any object is found to be stationary for a pre-defined period the system shall track the event and alert the operator. This facility may be provided on select cameras at Entry point, Boarding gates, and Arrival area and as defined by the Airport Operator/User. The system should have the features for identifying tail-gating, vehicle detection features, unattended baggage identification, queuing analysis, external text insertion feature and intruder detection. Various use scenarios of Artificial Intelligence based Video Analytics at Airports are mentioned in Appendix-1.
- 1.13 **Artificial Intelligence (AI) enabled Video Analytics and Face Recognition Software** shall be deployed on Servers at the CCTV Equipment Room within the Airport premises.
- 1.14 It shall provide video file export tool to export the native video format with all protections (e.g. digital certificate, encryption) for enabling to play this audio/video on a computer/Laptop.
- 1.15 The native file format audio/video player shall show the status of the

audio/video authentication as available with the original file format, to enable forensic officials to confirm whether audio/video file has been tampered with.

- 1.16** Video Management and Video Recording shall be deployed on Servers/Network Video Recorders. For Viewing and Monitoring of Cameras, requisite numbers of PC Workstations/Video Wall and Large format display monitors/LED walls shall be provided at CCTV Control Room. Required Storage shall be provided on Servers/Network Video Recorders or on Network Attached Storage (NAS)/ Storage Area Network (SAN).
- 1.17** In case of any failure or interruption of network, the Camera shall automatically start recording on Edge Storage Memory Card at resolution and frames per second as required and when the network recovers, the video data shall automatically be transferred to the Server/NVR without any impact on the system operations (Network Replenishment feature).
- 1.18** The system shall have diagnostics facility for Video & Network interfaces. System logging shall be possible either through system software or console port on the system.
- 1.19** The Recording shall be stored for at least 30 days for all Cameras with Full HD resolution and 25 FPS with H.265 or higher Video Compression.
- 1.20** Alarms shall be stored for at least 30 days.
- 1.21** The power supply available at the stations shall be 220 V / 50 Hz AC nominal and stabilized power from UPS to avoid fluctuation in the power supply. The UPS specification is out of the scope of this specification.
- 1.22** The CCTV Camera system and SVMS shall be time synchronized to IST using time server (that is NTP network time protocol), so that all devices of the system maintain same time.

SECTION- II

2 General Design/ functional parameters of SCCTV system

- 2.1 CAMERA SERVER software shall run on Commercial-off-the-shelf (COTS) Servers (Camera Servers & Database Server). Each Camera Server shall be able to handle 100 or more cameras. Camera, Database & Video Analytics Server will work as failsafe/redundant Server for each other.
- 2.2 VMS shall support failover for Recording, Management & Database Servers. Clustering shall be used for management and database server to provide high availability of application and recording servers should use native failover and users shall be able to play the video from failover servers without any manual interventions. Failover server video shall be synchronized with primary server once primary server is up.
- 2.3 Camera Server shall offer both video stream management and video stream storage management. Recording frame rate & resolution in respect of individual channel shall be programmable.

- 2.4 System shall ensure that once recorded, the video cannot be altered; ensuring the audit trail is intact for evidential purposes.
- 2.5 System shall provide sufficient usable storage of all the camera recordings in Full HD i.e. 1920x1080 or better for a period of continuous THIRTY (30) days on Serial Attached SCSI (SAS)/NL-SAS at minimum 25 FPS at 1920x1080 resolution or better quality using necessary compression techniques for all cameras (Extended capacities of Cameras i.e. present capacity +25%). In case thermal cameras are installed, recording of Thermal Cameras shall be as per their resolution @25FPS.
- 2.6 All the indoor cameras & control equipment shall be suitable for operation from 0° C to 40° C and relative humidity up to 80 % noncondensing. Cameras & other equipment, meant for outdoor installations, shall be suitable to work from (-) 10° C to (+) 55° C with RH up to 90% non-condensing. This temperature range may be achieved with or without heater.
- 2.7 Indoor cameras shall be either with vari-focal lens or Pan, Tilt & Zoom (PTZ) lens as per site requirement. All Cameras shall be Day/Night Wide Dynamic Range (WDR) and with Digital Noise Reduction (DNR) Colour Cameras. All Cameras should be with Infra-Red (IR) sensors.
- 2.8 All camera recordings shall have Camera ID & location/area of recording as well as date/time stamp. Camera ID, Location/Area of recording & date/time shall be programmable by the system administrator with User ID & Password.
- 2.9 Facility of camera recording in real-time mode (25 FPS) with option of lower FPS as well as in any desired combination must be available in the system.
- 2.10 Monitoring at Local control rooms may be restricted to operation of certain cameras only & System administrator should be able to configure the system, accordingly. More than one Local Control rooms may be required in the proposed system with individual configuration.
- 2.11 Database Server shall keep track of all configurations & events. This shall help in proper System administration & management of redundancies etc. suitable provision shall be made to keep database backup in same or another Server.
- 2.12 All the workstations in LAN should be provided with software to view and control the Cameras and retrieve the recorded video images from the CAMERA SERVER/NAS/SAN seamlessly.

2.13 Integration Interface with other system as per site requirement:

The system shall provide an integration interface to third party systems using well defined API SDK/ Open Database Connectivity. The API SDK for third party (Other system manufacturers involved in this project) shall be provided along the system without any additional cost,

which shall enable them to develop the software interface with CCTV system. The software shall have the inbuilt facility to seamlessly integrate to industry standards fire Alarm system & Building Management System (BMS) system and Baggage Handling System (BHS) with/without any SDK.

- 2.14 The Video Surveillance System shall be based on ONVIF, where the Video Management Software, Video Recording Software, Artificial Intelligence (AI) enabled Video Analytics Software and Face Recognition Software can work and integrate with any make of IT hardware like Server, Storage, Workstation, Network Video Recorder and Switches etc.
- 2.15 Required number of licenses shall be provided by OEM/Vendor for Video Management, Video Recording, Artificial Intelligence (AI) enabled Video Analytics and Face Recognition Software as per site requirement.
- 2.16 The Video Recording and Management System shall provide secured recording for evidence purposes and user authentication to protect data integrity.
- 2.17 Redundant Servers/NVRs shall be provided. The Redundancy System shall support defined number of Servers/NVRs in N+1 configuration (Value of N to be specified by the airport operator) so that the recording and playback availability is not affected in case of failure of any Server/NVR. The recording of last 30 days at any given point of time should be available through redundant Server/NVR in case of a Server/NVR failure. The recording should be available for users from redundant server without any manual intervention and disruption.
- 2.18 To ensure security of SVMS (Camera & Software) from vulnerabilities & breaches and discourage false undertaking from OEMs, security auditing and testing of equipment including source code of camera and software shall be carried out from STQC (Ministry of Electronics & Information Technology) and any other Government Agency from the list of CERT-In empanelled Information Security Auditing Organization. In order to ensure security of network and other IT equipment of the SVMS system, airport operator should ensure that cyber security auditing and testing at the time of POC (Proof of Concept) as well as at the time of completion of project are conducted or as specified.
- 2.19 OEMs must submit a declaration certificate regarding their genuineness, and shall not have 3rd party manufacturing from any company blacklisted in India or abroad (due to proven backdoor access and data vulnerability) or any country sharing land border

with India. The Intellectual Property Rights (IPR) of all manufactured final product and source code of all software including camera firmware, switch firmware, FRS algorithm, Command Control Centre Software etc. should not reside in countries sharing land borders with India, until unless specifically allowed by the Government of India and is registered with the Competent Authority of Government of India. Proof of IPR & source code residing in which country and requisite permission & registration with Competent Authority of Govt. of India, as applicable to comply with the above, shall be provided by the OEMs.

- 2.20 OEM need to confirm that the equipment, like Cameras etc., shall not be installed with standards like - GB28181, GB/T28181-2011, GB/T 28181-2011, GBT 28181- 2011, GBT28181-2011, GB/T28181-2016, GB/T28181-2022, GB/T25724 etc., protocols/standards and there shall be no option in the camera web page/settings to activate or deactivate such protocols/standards any of their version(s) or any such protocol which allow certain organizations to bypass all security parameters and look into the devices directly.
- 2.21 The MAC address of all cameras should not be registered in the name of any OEM/ company/ entity sharing land border with India until unless specifically allowed by the Government of India.
- 2.22 Mean Time Between Failure (MTBF) calculated at 40°C for each type of camera should not be less than 50,000 hours for which OEM shall submit complete and detailed test reports issued from Govt. / NABL Accredited Test Labs / 3rd party test house of international repute such as UL, TUV etc.

SECTION- III

3 Provision covered in video surveillance software system.

- 3.1 The software should provide for storage of configuration of cameras, IP Speakers, IoT Sensors, ANPR as applicable.
- 3.2 The software should come with a State of Art Graphical User Interface with interactive Geographic Information System (GIS) MAP for display of Camera location/ information.
- 3.3 The Graphical user interface (GUI) should be equipped with features such as map navigation features, measurement tools, Display and update of targets / intruders, display of text labels and annotations and top-level view of common operating picture.
- 3.4 The software shall support flexible 1/4/9/16/24/64 user defined Windows Split screen display mode or scroll mode on the PC/Workstation monitor/Video Wall or on preview monitor as per site requirement.

- 3.5 The software shall be able to control all cameras features such as PTZ control, Iris control, auto/manual focus, and colour balance of camera, Selection of pre-sets, Video tour selection, IoT Sensors etc.
- 3.6 The software is required to generate reports of stored device configuration. The control software is required to provide alarm and alarm log. The log shall be able to be archived, printed and displayed using a device filter, a device group filter and/or a time window.
- 3.7 The software shall have user access authority configurable on per device or per device group basis. The authorized user shall have the facility to request the access of any camera and can control the camera for a reservation period. Control of camera is released after the reservation period.
- 3.8 The system software shall provide User activity log (audit trail) with user id, time stamp, and action performed, etc.
- 3.9 The administrator shall be able to add, edit & delete users with rights. It shall be possible to view ability/ rights of each user or the cameras, which can be viewed & controlled as per the permission assigned by the administrator.
- 3.10 The users shall be on a hierarchical basis as assigned by the administrator. The higher priority person can take control of cameras, which are already being controlled by a lower priority user. There shall be minimum 03 hierarchical levels of security for providing user level log in.
- 3.11 The system software shall have recording modes viz. continuous, manual, or programmed modes on date, time and camera-wise. All modes shall be disabled and enabled using scheduled configuration. It shall also be possible to search and replay the recorded images on date, time and camera wise. It shall provide onscreen controls for remote operation of PTZ cameras. It shall have the facility for scheduled recording. Different recording speeds (fps) and resolution for each recording mode for each camera shall be possible.
- 3.12 It shall provide programmable motion detection and recording, to be defined area-wise. Open interface to receive Motion trigger and open interface to define the areas (at least four different areas) should be available from the cameras. System must be able to support video motion detection algorithms to detect and track objects, learn the scene, adapt to a changing outdoor environment, ignore environmental changes including rain, hail, wind, swaying trees and gradual light changes. On Detection, software must be able to generate an alarm (visual/audio) to the operator.
- 3.13 The settings shall be individually configurable for each alarm and each camera, pre-record duration. This shall allow the Camera Server to capture video prior to the alarm/event, as well as after the alarm/ event. Shall be selectable from a list of values ranging between 0 seconds and 5 minutes.

- 3.14 Data storage should be at a central location in the airport. The Capacity of storage should be for the period of continuous 30 days or more. For every 30 disks, one spare disk needs to be configured over and above required capacity. The storage system should follow FIFO on recording.
- 3.15 The software shall support web based user connecting via the Internet/Intranet and mobile OS (Android, iOS).
- 3.16 The software shall support a built-in Hardware or Software Watchdog monitor module. Watchdog Software shall monitor operation of all services and automatically restart them if they are malfunctioning.
- 3.17 The software should be able to receive alarm signal of the camera and should be able to send relay out signal through the camera.
- 3.18 The software shall provide a facility for any alarm input initiating any action in the SVMS system from third party integrations like ACS, FAS, BMS, BHS etc. The software should provide a reporting utility for tracking but not limited to the following options. Video and images shall be stored with reports for documenting events.
 - a) Alarms, Incidents, Operator logs, Service requests
 - b) The SMS/Email/WhatsApp Alert shall be generated in response to alarms triggered in SVMS software and sends out email alerts to a preconfigured list of recipients.
 - c) It shall be possible to export the settings of various entities within the SVMS i.e. Archive, Directory, cameras, warranty, etc. It shall be possible to print these reports
 - d) It shall be possible to get reports on past events by querying the audit databases. It shall allow the search by User Logon, Entity Configuration, Incident, Alarm, Application Failure, and Equipment Failure.
 - e) It shall allow passage of specific alarms to specified users rather than sending all alarms to every user.
- 3.19 The offered SVMS software should be ONVIF (Open Network Video Interface Forum) profile S, G, T & M compliant. The OEM of SVMS software should be full member of ONVIF.
- 3.20 The VMS must possess a security Vulnerability Assessment and Penetration Testing (VAPT) certification. This certification must be obtained through an agency empanelled by the CERT-In.
- 3.19. Artificial Intelligence (AI) enabled Video Analytics Software:
 - A) Possible applications of Artificial Intelligence (AI) enabled analytics software

for specified number of Cameras (to be decided by AO, BCAS, ASG/APSU, IB) shall include the following minimum Artificial Intelligence (AI) enabled video analytics software.

- i) Intrusion Detection
- ii) Camera Tampering
- iii) Loitering Detection
- iv) Human & Vehicle Detection (also unauthorized/suspicious parking)
- v) Search of Humans based on Attribute
- vi) Colour Search
- vii) Fallen Person
- viii) Combination Search (Human/Vehicle & Colour)

Video Analytics system should have capability of integration with VMS. It should be possible to configure any of the camera from VMS application.

Note: The software shall have filters to distinguish between humans/animals and vehicles/ objects.

Search of Humans based on Attribute:

1. The AI should be able to sort through hours of video with ease, to quickly locate a specific person of interest. Attribute Search should improve incident response time and enhance forensic investigations by helping operators compile robust video evidence, create a powerful narrative of events, and reveal an individual's route or last-known location.
2. AI software should allow operator to mark a person who has been identified as a suspect in any playback video or in live mode. It should then have the capability to track and search the objects movements across multiple cameras based on the Attribute of the person and show the results so that the user can track the movement of the person across cameras.
3. In the event when a suspect's face is not captured clearly or not recognizable due to any reason, the AI software should allow operators to search a Person based on a person's Attribute characteristics and retrieve intelligent information to locate a specific person or vehicle of interest across multiple recorded video streams from FHD Bullet/Box, Dome cameras.
4. It should sort through hours of video across all the station cameras with ease, to quickly locate the specified person across cameras based on his Attribute, reducing search time from day and hours down to minutes.

Colour Search:

5. In the event when suspect face is not clearly visible, in such case a colour base

detection and search should be available with Artificial Intelligence (AI) enabled video analytics.

Fallen Person

6. In case of any person falling due to any reason should be detected.

Combination Search (Human/Vehicle & Colour)

7. Artificial Intelligence (AI) enabled video analytics should be able to search for suspects with combination of search criteria like Colour and Object (Human / Car).

B) Artificial Intelligence (AI) enabled Video Analytics Software can be implemented at server (which should be able to work 24x7, 365 days) level in the control room.

C) The Artificial Intelligence (AI) enabled Video Analytic server shall support redundancy with N:1 redundancy configuration for Artificial Intelligence (AI) enabled Video Analytic Servers.

D) Security Verification Certification: The Artificial Intelligence (AI) enabled Video Analytics Software shall have security features which can be deployed meeting the security assurance requirements for security, vulnerabilities and verified from the STQC (Ministry of Electronics & Information Technology) or any other Government Agency from the list of CERT-In empanelled Information Security Auditing Organization for testing and issuing the certificate / clearance.

3.20. Face Recognition Software:

- i. Face Recognition System shall work on real time and offline mode.
- ii. The system shall capture face images from live CCTV video feed and generate alerts, if blacklist match is found. FRS alerts should be pushed to the Video Management System/ NVR. (Seamlessly integrated with Video Management System /NVR).
- iii. The system shall have the best suited technology employed for 1: N (one to many) matching application when they enter the field of view of CCTV Cameras. It should have a 1:1 (one to one) verification feature for Access control systems at some locations as required.
- iv. The system shall have the provision to take multiple samples of same face belonging to same person.

- v. The system shall be able **to** work on moderate face rotation either horizontal or vertical. It should support a yaw angle of -40 to +40 degrees, a pitch angle of -30 to +30 degrees and a roll angle of -20 to +20 degrees.
- vi. The system shall be able for matching suspect faces from pre-recorded video feeds obtained for CCTV deployed various identified locations.
- vii. The system shall be able to add photographs obtained from law enforcement agencies to the criminal's repositories along with option details for sex, age, etc. for future searches.
- viii. The system shall support diverse graphic & video formats as well as live Cameras.
- ix. The identification of faces should be contactless, at a distance and on the move and in the crowded area.
- x. The system shall have in-built tool with capability to build partial faces and enhancement of quality of image before enrolment.
- xi. The system shall be able to utilize any of the file formats like JPEG, PNG, BMP, TIFF etc. format for enrolment for matching.
- xii. The system shall be able to check if new enrolled face is already enrolled in the data base before registering the new enrolled face in the system.
- xiii. The system shall have option to enrol face images from CCTV Cameras.
- xiv. The system shall have capacity to create different categories of people with option to customize the matching threshold for different categories.
- xv. The system shall be able to work on full HD.
- xvi. The system shall be able to be implemented on IT hardware like Server (which should be able to work 24x7, 365 days).
- xvii. The system shall be able to use latest CPU and GPU based processing for multiple Camera streams in a single Server (which should be able to work 24x7, 365 days).
- xviii. The system shall be able to work on windows / Linux operating system.
- xix. The system shall employ database system like MS SQL or Oracle or PostgreSQL or

MongoDB or any other data base system.

- xx. The system shall have the capability to have face image data base up to 10,00,000 (or as specified by the purchaser) for 1 : N matching. The system should be scalable to upgrade for higher data size as and when required with additional license for data base.
- xxi. The system shall be able to work on cameras which are included in this specification.
- xxii. a) The Face Recognition Algorithm should have participated and have been established in the Face Recognition Algorithm Evaluation conducted by NIST (National Institute of Standards and Technology, U.S. Department of Commerce) The NIST benchmark/ latest performance FRVT test results of current calendar year with respect to the opening date of tender or last 1 preceding year, the performance efficiency of the algorithm shall be within the top 25 ranked algorithms of the FRVT (1:N) test results with FNIR (N=1.6M, T=0, Rank=1).
- b) The FRS system shall be enterprise grade highly scalable providing most accurate results for the most demanding real time and post event off line mode.
- c) The system shall work on partial occlusion of face, glasses scarf changes of facial expression etc. The FRS system should also overcome challenges such as crowded environment, poor lighting, moving subjects, angle and distance.
- xxiii. The image Database Server shall support redundancy with N:1 redundancy configuration.
- xxiv. Security Verification Certification: The Face Recognition Software shall have security features which can be deployed meeting the security assurance requirements as per Relevant clauses / paras to be applicable for security, vulnerabilities from STQC (Ministry of Electronics & Information Technology) or any other Government Agency from the list of CERT-In empanelled Information Security Auditing Organization for testing and issuing the certificate / clearance.

3.21. **Software License:**

- 3.21.1 OEM/Vendor shall offer required number of licenses for Video Management, Video Recording, Artificial Intelligence (AI) enabled Video Analytics and Face Recognition Software for all the Cameras, NVRs, Servers, PC workstations, Clients etc. as per requirement.

3.21.2 The Licenses shall be of life-time type. Licenses related compliance shall be ensured by purchaser depending upon the requirement.

3.21.3 All software license(s) should be provided as Paper License in favour of purchaser/ user.

3.22 Acceptance Test:

3.22.1 Face Recognition Software: The Face Recognition Software shall be tested for its performance as per clause above along with required no. of Cameras, Server/Workstation and other required devices & equipment's.

3.22.2 Any other tests shall be carried out as considered necessary by the inspecting authority.

SECTION- IV

4 User Facilities covered in application software

4.1 The user shall consist of Administrator Tool application, a Monitoring application, and an Archive Player application.

4.2 The client shall perform the following applications simultaneously without interfering with any of the Archive Server operations (Recording, Alarms, etc.):

- a. Live display of cameras
- b. Control of PTZ cameras
- c. Playback of archived video
- d. Retrieval of archived video
- e. Instant Replay of live video
- f. Configuration of system settings

4.3 The user applications shall provide an authentication mechanism, which verifies the validity of the user.

4.4 The user shall be able to define bookmarks, the amount of time he wishes to go back from a predefined list or through a custom setup period.

4.5 The user shall be allowed to add bookmarks to recorded clips of video.

4.6 The user shall be able to choose and trigger an action from a list of available actions included but are not limited to:

- a. View camera in a video tile
- b. View Map or procedure in video tile.
- c. Starting/ stopping PTZ pattern
- d. Go to PTZ preset

- e. Sending alert messages
- 4.7 The user shall be capable to display all camera sequences created in the system.
- 4.8 The user shall be allowed for unlimited cameras sequences, which can be run independently of each other on either of the monitor tiles.
- 4.9 The user shall be able to drag and drop a camera from a tree of available cameras into any video tile for live viewing.
- 4.10 The user shall support digital zoom on a fixed/ PTZ camera's live and recorded video streams.
- 4.11 The user shall be able to control pan-tilt-zoom, focus and dome relays.
- 4.12 The user shall be allowed to access the PTZ configuration menus with no need of additional hardware.

SECTION- V

5 DETAILED TECHNICAL SPECIFICATIONS

5.1 IP PTZ Day/Night Colour 4 Mega Pixel Camera:

Parameter	Proposed Specifications
Image Device:	1/2.8" or better progressive CMOS sensor
Optical zoom (For Indoor Camera):	20 x or better
Optical zoom (For Outdoor Camera):	30 x or better
Number of Pixels:	2560 x 1440 or better
Resolution:	4 MP or better
Minimum Illumination:	B/W: 0.1 Lux or better Colour: 0.6 Lux or better
Wide Dynamic Range (WDR):	120 dB or better

Pan Travel:	360° Continuous
Tilt Travel:	0 - 90°, Auto flip
Manual Tilt Speed:	0.5°/SEC to 90°/SEC
Manual Pan Speed:	0.5°/SEC to 90°/SEC
Preset Tilt Speed:	0.5°/SEC to 90°/SEC
Preset Pan Speed:	0.5°/SEC to 270°/SEC
Video Stream:	Dual H.265 or better video stream for independent viewing and recording
Auxiliary inputs & outputs:	1 alarm input, 1 relay output
Privacy masking zones:	8 or more
Preset positions Min:	128
Iris Control:	Auto
Focus:	Auto
White balance:	Auto
Electronic shutter:	Auto
Remote access:	Via browser for configuration, viewing and control
Ethernet:	10/100 Base-T Auto sensing, Half /Full Duplex (RJ45)
S/N Ratio:	>= 55 dB
SD Card Slot:	SD card slot with support for Micro SD, SDHC or SDXC cards up to 512 GB, and populated with 256 GB, AES encrypted.
Standard:	BIS standards as mentioned below: <ul style="list-style-type: none"> i. For safety – IS 13252-1 (2010): “Information Technology Equipment – Safety, Part 1”; and ii. For performance – IS 16910 (Part 5) 2020: “Video Surveillance Systems for Use in Security Applications”.
Compliance	ONVIF (Open Network Video Interface Forum) Profile S, G, T & M compliant

Power supply (Indoor type):	Shall have the ability to be powered by PoE+ 802.3 as well as DC/AC power adapter
Power supply (Outdoor type):	Power Supply should be of the same OEM of Camera
Cyber security:	User account and password protection, HTTPS, IP filter, Digest authentication, TLS 1.2 stream encryption, AES 256 / RSA encryption for video data.
Edge based / Server based analytics:	Auto Tracking
Health Monitoring:	Camera should have inbuilt browser-based dashboard to show details of Active connection, Camera Bandwidth, Network Port utilization, Camera Uptime, CPU Load and Camera Temperature.

5.2 IP Day/Night Fixed Colour 4 Mega Pixel Camera

Parameter	Proposed Specifications
Image Device:	1/2.8" or better progressive CMOS sensor
Lens :	OEM Varifocal lens, Auto/ programmable Iris, lens f ~ 3 mm to 9 mm ($\pm 25\%$ for Indoor Dome/Bullet Camera) & f ~ 10 to 40 mm ($\pm 10\%$ for Outdoor Box/Bullet Camera) or better
Number of Pixels :	2560 x 1440 or better
Resolution:	4 MP or better
Minimum Illumination :	B/W: 0.1 Lux or better; Colour: 0.6 Lux or better
Video Stream:	Dual H.265 or better video stream for independent viewing and recording
Electronic Shutter:	Auto
Auxiliary / Digital inputs & outputs:	1 alarm input, 1 relay output
Iris Control:	Auto
White balance:	Auto
Wide Dynamic Range (WDR):	120 dB or better

Remote access:	Via browser for configuration, viewing and control
Ethernet:	10/100 Base-T Auto sensing, Half/ Full Duplex (RJ45)
S/N Ratio:	>= 55 dB
IR Illuminator	Inbuilt IR (Range 30 Meters or Better)
SD Card Slot:	SD card slot with support for Micro SD, SDHC or SDXC cards up to 512 GB and populated with 256 GB, AES encrypted.
Standard:	BIS standards as mentioned below: <ul style="list-style-type: none"> i. For safety – IS 13252-1 (2010): “Information Technology Equipment – Safety, Part 1”; and ii. For performance – IS 16910 (Part 5) 2020: “Video Surveillance Systems for Use in Security Applications”.
Compliance	ONVIF (Open Network Video Interface Forum) Profile S, G, T & M compliant
Power supply (Indoor type):	Powered by PoE 802.3/ normal DC/AC power / PoE converter.
Power supply (Outdoor type):	Power Supply should be of the same OEM of Camera or OEM certified as per OEM’s design.
Cyber security:	User account and password protection, HTTPS, IP filter, Digest authentication, TLS 1.2 stream encryption, AES 256 encryption
Edge based analytics:	<ul style="list-style-type: none"> • Object in field, crossing line, Entering field, Leaving field, Loitering, • Wrong way detection • Idle object, Removed object, Occupancy, • Passenger counting, Crowd detection, Tampering, • Object classification (person)
Health Monitoring:	Camera should have inbuilt browser-based dashboard to show details of Active connection, Camera Bandwidth, Network Port utilization, Camera Uptime, CPU Load and Camera Temperature.

5.3 IP PAN/TILT THERMAL CAMERA

Parameter	Proposed Specifications
Image Device:	Long Wave Infra-red
Lens:	35/50/100 mm or more (As per site requirement)
Number of Pixels:	640 x 480
Pan Travel:	360° Continuous
Tilt Travel:	-70° - 0°
Video Stream:	2 simultaneous
Auxiliary inputs & outputs:	1 alarm input
Frame Rate:	1 to 25 FPS
Remote access:	Via browser for configuration, viewing and control
Ethernet:	10/100 Base-T Auto sensing, Half /Full Duplex (RJ45)
Housing (Outdoor):	IP 66, IK 10 rated.
Standard:	BIS standards as mentioned below: For safety – IS 13252-1 (2010): “Information Technology Equipment – Safety, Part 1”.
Compliance:	ONVIF (Open Network video Interface Forum) S, G, T & M compliant
Power supply (Outdoor):	As per OEM’s design, however generally AC 230 V @50Hz/ 12V or 24 V AC

Work Station (Type-A: For Video wall and Field Monitors; Type-B: For SCCTV Operator)

Parameter	Proposed Specifications
CPU:	Type A : Minimum 14th Generation Core i7 Intel/ AMD Ryzen 7 8700G Processor operating at 3 GHz Base clock or higher, 30 MB Cache or higher, 14 core processor . Type B : Minimum 14th Generation Core i7 Intel/ AMD Ryzen 7 8700G Processor operating at 2.6 GHz Base clock or higher, 30 MB Cache or higher , 8 core processor.
Memory:	Type A: 64 GB DDR 5 or Higher Type B: 32 GB DDR 5 or Higher
Hard Drives:	Type A & B: 256 GB NVMe SSD and 1TB HDD

RAID:	Type A & B: Supported
Mother Board :	Type A & B: Original
Keyboard:	Type A: Wireless Keyboard Type B: Wired Keyboard
Mouse:	Type A: Wireless Optical Mouse Type B: Wired Optical Mouse
Video Card:	Type A: Minimum NVidia RTX or AMD Radeon Pro Quad Ports Graphics Card with 16 GB Video Memory or Higher. (two no's graphic card for more than 50 camera viewing concurrently in video wall) and Field Monitors Type B: Minimum NVidia RTX or AMD Radeon Pro Quad Ports Graphics Card with 8 GB Video Memory or Higher (one number graphic card)
Network Adapter (NIC):	Type A: Minimum Two 10G Ethernet Ports with Bluetooth. Type B: Minimum Two 1G Ethernet Ports with Bluetooth.
Sound Card:	In- Built
DVD writer:	DVD RW/ Blu Ray combo internal/external
Monitor/Video Wall support:	Type B: 24" Full HD LED Display with HDMI/DP Connectivity
Ports:	One Display port, One HDMI port, Two USB at front panel, One USB at rear panel and at least one USB C Port (front/rear)
Operating system:	MS Windows OS or Linux (Latest versions)
Anti-Virus Software:	Anti-Virus Software compatible with Windows/ Linux (Latest version)

5.4 Network Video Management and Recording Server (For SCCTV System having 50 or less cameras)

Parameter	Proposed Specifications
Channels	64
Video Management and Recording	One 64 Channel appliance shall support Video Management and Recording of 64 nos. of Cameras with required Storage
Recording Bandwidth	400 Mbps or higher

Storage Capacity (Built-in)	72 TB or more
Video Playback	25 Channels simultaneously or higher
Power Supply	230 VAC
Performance	Should be able to run 24x7 at ambient room temperature of 27 °C.
Operating System	Embedded Windows server 2022 or higher / Linux
Video Compression	H.265 or higher
Drive	SATA for data recording SSD for operating system
Network Protocols	Suitable and required network protocol stack to work Camera in TCP/IP based Ethernet network environment. (as required for system working)
Discovery Interface	OEM interface to detect the camera automatically and configure network settings
Network Interface	2 RJ45 Gigabit Ethernet LAN ports (teamed)
Video Output	Two Digital 4K HDMI/DP Output
USB Interface	4 X USB 3.2 ports
Monitoring	SNMP, Remote Desktop and HTTP monitoring support.
Software Features	Video Management Software & Graphic User Interface Client Software and Video Recording Software shall be as per Software Requirement of the specification.
Security	On Board TPM crypto processor
Storage Drive Raid configuration	Raid 6 (recording server)
OS Drive	2 x 240 GB (RAID 1)
Audio out	1
Multi Screen	1,4,6,8,9,16,25,36,64

5.5 Camera/Database/Video Analytics/FRS Server (For SCCTV System having more than 50 cameras):

CPU:	Minimum Two Processor 12 Core each or higher Intel/AMD CPU operating at 3.0 GHz or more with a minimum of 24 MB cache or higher
Memory:	64 GB (DDR5) RAM Upgradable to 128 GB
OS Drive	2 x 240 GB (RAID 1)
Database transaction storage drive	SSD – 1 TB (minimum) and actual based on the alarm retention. (RAID 1 or higher)
Chassis type:	Rack mountable

Hard Drives:	SAS 10K rpm or higher hot swappable Hard Disk in RAID 6 configuration having usable space of 1TB or more.
Power supply:	Hot Swappable Redundant Power Supply
Network Adapter (NIC):	Quad 1Gbps ports
Keyboard:	USB Keyboard
Mouse:	Optical Mouse with scroll
Operating system:	MS Windows OS or Linux (Latest versions)
Anti-Virus Software:	Anti-Virus Software compatible with Windows/ Linux (Latest version)
Security	EAL2+ certified, Cryptographically verified trusted booting standard
GPU (for Video Analytics & FRS Servers)	2 x Nvidia L4 24 GB or better
Regulatory Approvals/ Certifications	BIS (IS-13252 : Part 1 : 2010 or latest) certification for Safety and BIS/CE/FCC Certifications for EMC & Immunity.
USB Port	Should be Available

5.6 NAS/SAN Storage:

- 5.6.1 NAS/SAN Storage System with RAID 6 configuration shall be used to record video streams based on the configuration assigned by administrator. Workstations & Servers within the LAN should be able to access the recorded video streams. The Storage device shall support simultaneous playback and recording at full duplex operation.
- 5.6.2 It shall provide a high-quality recording storage and play back of images. It shall support integration with LAN to provide Centralized Management and shall operate on Windows/ Linux/ UNIX OS. Support of user management for security level control and authentication required. These Storage devices shall have the following features and specifications:

Parameter	Proposed Specifications
Controller	Dual Active-Active Controllers in active failover mode with no single point of failure
Onboard Cache	128 GB Mirrored and scalable to 256 GB

Storage Disk	7.2K/10K rpm SAS/ NL-SAS disk for 30 days
Host Interface	At least Four 10G Ethernet and Four 32G FC Ports
HDD type support (Any one)	SAS, SSD, NL-SAS
Inbuilt RAID Support	RAID- Double Disk failure support/ RAID-6
Network Transport Protocols	TCP/IP
Server /Storage should support Protocol (As per solution) (Any one)	CIFS/ NFS/ iSCSI/ FCP/ HTTP/HTTPS/ FTP/ NTP/ SNMP/ SMTP/ DHCP and DNS
Operating System (OS)	Single unified built-in Storage OEM OS for all the protocols, Compatible with MS Windows/ Linux/ Unix
Power supply	Hot Pluggable Redundant Power Supply
Storage File Management Software	Inbuilt CLI & Web Based GUI administration management software
Mounting arrangement	Rack mountable
Scalability	The storage offered shall be scalable to add additional 50% usable capacity at site within the same storage.
Storage System should be provided with	No other upgrades should be required for desired scalability except for disk Arrays enclosures and Disk drives as required. Once data is stored in Storage, no client/operator should be able to delete or modify data.

5.7 Network Switches:

- a. All network equipment should be preferably from One OEM. MAC address of switches should be in name of OEM.
- b. Ethernet Network shall consist of Layer 3 Core Switches should in Active-Active HA Mode in Equipment/Server room.
- c. Ethernet Network shall consist of Layer 2 PoE+ Edge Switches in field interconnected via Single Mode OFC Cables only in such a manner that there is no single point of failure.
- d. Minimum PoE+ Power Budget should be 320 Watts per switch to provide adequate Power to PoE Devices.
- e. No Two Layer 2 switches to be interconnected via LAN or CAT-6 Cables in the field network.

- f. All Switches installed outside Building premises should be Industrial Grade.

5.8 LED Display Monitor (Specifications are indicative):

Screen Size:	55" (diagonal) or higher
Monitor Type:	Industrial/ Professional suitable for 24x7 operation
Back Light:	LED
Panel Technology	IPS (Inplane Switching)
Aspect Ratio:	16:9
Resolution:	Full HD, 1920 X 1080 pixels or better, should support UHD resolution
Brightness:	700 cd/m ² or better
Dynamic Contrast Ratio:	4,50,000:1 or better
Viewing angle:	178°
Operating Voltage :	Suitable for single phase AC supply 180-230 V, 50 Hz
Video Input Ports:	Ports: HDMI-2, DP, DVI-D-1; USB-1, RJ-45 (LAN-1)
Certification:	UL for safety, FCC for EMC and BIS

5.9 Video Wall (As per site requirement)

- 5.9.1 2x2 (4 Panels)/3x2 (6 Panels) or higher as per requirement. Thin bezel Industrial Video Wall Displays with Common Control Room Client Workstation complete with wall/ceiling/floor mounting arrangement as per specifications.
- 5.9.2 Video wall shall be Hardware/Software clustered displays with Client Workstation. 55" LED Thin Bezel Monitor with mounting accessories for display of video images of all cameras in Common Control Room as per following specifications:

Parameter	Proposed Specifications
Screen Size:	55" 3x2 (6 Panels)/ 2x2 (4 Panels) or higher as per requirement
Aspect Ratio:	16:9

Display Type:	Industrial/ Professional suitable for 24x7 operation
Panel Technology	IPS (Inplane Switching)
Brightness:	700 cd/m ²
Dynamic Contrast Ratio:	4,50,000:1 or better
Viewing angle:	178°
Resolution:	Full HD, 1920 X 1080 pixels or better, should support UHD resolution
Operating Voltage:	Suitable for single phase AC 180-230 V AC, 50 Hz
Video Input Ports:	Ports: HDMI-2, DP, DVI-D-1; USB-1, RJ-45 (LAN-1)
Output Ports:	Display port for daisy chain to run FHD content without controller, RJ-45 (LAN-1)
Bezel	Thin Bezel design: Bezel width 0.45 mm or better; Bezel to Bezel (Gap) : 1.0 mm or less
Certification:	UL for safety, FCC for EMC and BIS

5.10 Camera Housing & mount:

Housing (Indoor):	IP 54, Shall be of same make as of camera.
Housing (Outdoor):	IP 66 rated shall be of same make as of camera. Outdoor PTZ camera may be IK10 certified for vandal proof rating.
Mount:	Standard mounting of same make as of camera shall be supplied for Surface/Ceiling/pipe/corner/parapet/pendant with wall mount bracket/In Ceiling. Any extension to standard mounting according to site requirement may be supplied indigenous item.

5.11 Cables:

- 5.11.1 L3 Switch to L2 Switch: OFC
- 5.11.2 L2 Switch to Cameras: UTP Cat 6

Annexure-1**Area wise proposed/possible Use of Artificial Intelligence (AI) based Video Analytics, but not limited to.****i. Security and Surveillance Specific Use**

Sl. No.	Purpose	Use of AI based VA	Area/Location/Security Check Points	Security and Surveillance requirement	
1.	Identifying and detecting person	Facial recognition	<ul style="list-style-type: none"> ▪ Departure Entry ▪ Access Control points ▪ Check-in area ▪ Terminal building security check points ▪ Sterile Hold Area ▪ Boarding Area ▪ Arrival Area 	<ul style="list-style-type: none"> ▪ Identification and Detection of Person of Interest ▪ Tracking a Person of Interest ▪ Investigation 	
2.	Tracking Person	Person identification	<ul style="list-style-type: none"> ▪ Arrival Hall ▪ Arrival Exit Gate ▪ Arrival Forecourt ▪ BMA & BBA ▪ Apron and Ramp Area 		
3.	Identifying and detecting unattended object	Unattended object detection	<ul style="list-style-type: none"> ▪ Departure Forecourt ▪ Departure Entry ▪ Check-in area ▪ Sterile Hold Area ▪ Boarding Area 	<ul style="list-style-type: none"> ▪ Identification and Detection of Object of Interest ▪ Anti-sabotage measures ▪ Investigation 	
4.	Tracking Object	Object identification and tracking	<ul style="list-style-type: none"> ▪ Arrival Area ▪ Arrival Hall ▪ Arrival Exit Gate ▪ Arrival Forecourt ▪ BMA & BBA ▪ Apron and Ramp Area 		
5.	Intrusion Detection	Vertical movement detection	<ul style="list-style-type: none"> ▪ Perimeter Wall/Area ▪ Terminal Building ▪ Aircraft Parking/ Hangar Area 	<ul style="list-style-type: none"> ▪ Prevention of Intrusion/ Perimeter scale over 	To be taken in PIDS work

			<ul style="list-style-type: none"> ▪ ATC ▪ Apron and Ramp Area 	<ul style="list-style-type: none"> ▪ Prevention of scale over/unauthorized entry into Airport facilities
6.	Suspicious Movement detection	Detection of Loitering in sensitive/airside area, leaving baggage unattended	<ul style="list-style-type: none"> ▪ Terminal Building ▪ Departure/Arrival Forecourt ▪ Alighting point 	<ul style="list-style-type: none"> ▪ Anti-sabotage ▪ Prevention of criminal activities
7.	Prevention of Tailgating	Tailgating/Forcible Entry Detection	<ul style="list-style-type: none"> ▪ Access Control Points ▪ Card based access points ▪ Staff Gate 	<ul style="list-style-type: none"> ▪ Prevention of unauthorized entry into airside
8.	Vehicle Recognition and Tracking	Automated Number Plate Recognition	<ul style="list-style-type: none"> ▪ Entry/Exit Naka ▪ Alighting point ▪ Vehicle gates. 	<ul style="list-style-type: none"> ▪ Identification of false Reg. No. ▪ Detection of Vehicle of Interest
9.	Detection of Commotion/Altercations/Use of Force	Unusual Behavior/Pattern Detection	<ul style="list-style-type: none"> ▪ Access Control Gates ▪ Terminal Building 	<ul style="list-style-type: none"> ▪ Detection of Forced Entry

ii. Analysis and Planning

Sl. No.	Purpose	Use of AI based VA	Area/Location/Security Check Points	Analysis and Planning requirement
1.	Analysis of passengers' footfall, baggage, etc.	Passengers' and Baggage counting	<ul style="list-style-type: none"> ▪ Departure Entry ▪ Check-in area ▪ Sterile Hold Area ▪ Boarding Area ▪ Arrival Area 	<ul style="list-style-type: none"> ▪ Assessment on congestion ▪ Screening Channel requirement

2.	Queue management	Overcrowd detection at Access Points	<ul style="list-style-type: none"> ▪ Departure Access points ▪ Check-in area ▪ Sterile Hold Area 	<ul style="list-style-type: none"> ▪ Real Time Queue management ▪ Analysis & Planning on
3.	Peak hour s management	Rush/Crowd detection a t Access/PESC points	<ul style="list-style-type: none"> ▪ Boarding Area ▪ Arrival Immigration/ Customs area (Intl. Airport) 	optimum use of man & machinery
4.	Data on Male and female travelers	Counting of Male/female Passengers		<ul style="list-style-type: none"> ▪ Manpower Deployment ▪ Resource allocation; especially for male/female screening channels
5.	Vehicle Counting	Counting of Vehicles	<ul style="list-style-type: none"> ▪ Entry/Exit Naka ▪ Departure/Arrival Road 	<ul style="list-style-type: none"> ▪ Analysis & Planning on optimum use of man & machinery

iii. Passengers' Need/Facilitation (not mandatory)

Sl. No.	Purpose	Use of AI based VA	Area/Location/Security Check Points	Pax Need & Facilitation
1.	Medical/Trauma/ Shock case/ Accident detection	Fall detection/ Collapse of structure detection	<ul style="list-style-type: none"> ▪ Departure Forecourt ▪ Departure Entry ▪ Check-in area ▪ Sterile Hold Area ▪ Boarding Area ▪ Arrival Area ▪ Arrival Hall ▪ Escalators/ Travelator 	<ul style="list-style-type: none"> ▪ Assistance in medical issue of passengers ▪ Help in Accident/ collapse cases

2.	Tracking of lost Children	Reverse Tracking of person/ children	<ul style="list-style-type: none"> ▪ Terminal Building ▪ Sterile Hold Area ▪ Boarding Area ▪ Departure/Arrival Forecourt ▪ Adjacent area in City side 	<ul style="list-style-type: none"> ▪ Detection and uniting children separated at the airport
3.	Tracking of Lost/misplaced Baggage	Reverse Tracking of Baggage	<ul style="list-style-type: none"> ▪ Parking Area ▪ Alighting point ▪ Arrival city side 	<ul style="list-style-type: none"> ▪ Detection and restoration of lost/misplaced baggage of Pax

TECHNICAL SPECIFICATION OF IPPBX SYSTEM

1. Introduction:

The following details specify the scope of work, design & technical specification for all the IPPBX Works in the new Terminal building. It comprises the systems listed out in this document and defines a turnkey solution.

2. Scope of Work:

The following details specify the scope of work, design & technical specification for all the IPPBX Works in the new Terminal building. It comprises the systems listed out in this document and defines a turnkey solution.

- **IP-PBX:** - UTP cable shall be laid for voice points by EPC Contractor. IPPBX exchange shall be established including direct PRI line also. Separate UPS connectivity shall be provided to exchange server.
- **AMC/ Warranty** – All product shall be offered with 2 years OEM Warranty from the date of completion of commissioning. After 2 Years, products shall be under 5 Years AMC with OEM Support/ Service for all items. All Inclusive Comprehensive Maintenance of IPPABX and its associated system for 5 years after DLP including trouble shooting, preventive maintenance and breakdown maintenance, supply of all spares and accessories and replacement of batteries of UPS as required etc. as required as per good engineering practice, recommendation of the manufacturer, instructions of Engineer-in-Charge/ as per terms and conditions specified.

3. General Guidelines:

i. Terms & conditions

- Payment against AMC shall be made quarterly after successful completion of services in the quarter.

ii. General Guidelines regarding Offered Products

- 1) The capacity given in the specification is minimum and Contractor has to provide as per requirement.
- 2) All Electrical/ Power Requirement shall be designed accordingly. UPS power supply for 24 x 7 to all Active Networking Equipments is mandatory.
- 3) UPS supply shall be provided to IPPBX Components installed at Field/ Remote Racks for uninterrupted service during power down.

- 4) OEM of all offered products shall have Technical Support Center presence in India.
- 5) There shall be compatibility of network with existing equipment at the airport (if applicable).
- 6) All Covered Cable Trays, concealed Conduit and other accessories like HDPE/GI Pipe Channel Conduit shall be provided for the passive cabling works by Engg-Electrical Contractor as per site requirement.
- 7) Cable Tray/ HDPE/ GI Pipe/ Conduit/ Channel conduit shall be confirming to the specifications similar to respective engineering items.
- 8) The offered equipment by the Contractor shall be fully complied with the specifications to full fill the requirements. Higher specifications suitable to requirement can be accepted. The offered products shall be complied by the standards given in the specifications or its equivalent standards in respective category.
- 9) The design and selection of the offered IPPBX networking components by the Contractor shall be consistent with the requirements of long-term trouble-free operation with highest degree of reliability and maintainability.
- 10) The offered equipment by the Contractor shall be designed for continuous operation (24-hours a day and 365-days a year).
- 11) All offered equipment shall be standard proven product already available in the market. Offered Item shall not be end of life or end of sale.
- 12) MAF & a letter from OEM shall be submitted in regards of warranty support & Non-Refurbished items, and no End of Life/ End of Sale against the offered product. OEM has to ensure that the support shall be provided for the offered products during the concurrency of the contract.
- 13) All types of spares and spare modules of the offered equipment shall be readily available with the Contractor during life-time of the equipment, for maintenance, repairs and up keep of the equipment during warranty & CAMC period, if applicable.
- 14) The offered equipment by the Contractor shall furnish the details of EMI and Safety Standards met by his equipment and built-in safety features.
- 15) The offered equipment shall be constructed on a modular basis, using plug-in type units and components to the extent possible. Parts subject to failure, wear, corrosion or other deteriorations or requiring occasional inspection, adjustment or replacement shall be made accessible and capable of convenient inspection and removal.
- 16) All offered/ supplied Hardware system/ component and Software by Contractor shall be licensed, as applicable, in favor of Airports Authority of India and valid for lifetime of the offered system.
- 17) Contractor has to offer/supply Passive Cabling Components as specified in the NIT or better and latest upgrade model/ version if available in the market at the time of execution.

18) Items mentioned in document is minimum. Contractor has to provide all requisite accessories/ items which are not included in the document to document to achieve the functionality of the NIT.

iii. General Guidelines Regarding Contractors

1. Installation/ Configuration shall be carried out by technically well qualified and certified personnel as per the requirements.
2. Contractors shall not outsource any part of the contract to any other vendor/ third party contractor without prior permission of AAI.
3. Liability, if anything arising out of such third party contracts to any other vendor by contractor shall be to the contractor's account.
4. AAI shall not be liable on behalf of contractor to any other third party contractor/ Government of India/ State/ Regulatory Authorities.
5. Any liabilities arising out of such third party contracts by contractor or its men working at site shall be only to contractor's account and shall be deducted out of its running bills.
6. Contractor shall submit Police Verification Certificates and obtain necessary Airport Entry Permits, for allowing its men to work at AAI restricted premises.
7. Vendor has to survey for final bill of quantity before implementation of work or procurement or approval from AAI Site In-charge.

4. Site Acceptance Test (SAT) & Commissioning:

- 1.1 It shall be the responsibility of the Contractor firm to submit the system test procedure for conducting the post-installation site acceptance testing. The procedure submitted by the Contractor firm shall be drafted in line with the standard practices followed in the industry and shall be in accordance with the test procedures & practices specified by the OEM. The acceptance test procedure on approval by AAI shall become the document for acceptance of the equipment after installation at the site.
- 1.2 The draft copy of system test procedure shall be made available to AAI before **THIRTY** calendar days of the scheduled site acceptance date.
- 1.3 The Contractor firm shall supply, install, test and commission all hardware and software as per the requirement of the tender with the system. Contractor firm shall supply Technical documents (hard and soft copy – one set each) at site. The system shall be commissioned after successful completion of - SAT approval, operational & maintenance training and all the works under the scope of the tender.

5. Patent's, Liability & compliance of regulations

- 1.1 Contractor firm shall protect and fully indemnify AAI from any claims for infringement of patents, copy right, trademark or the like.

- 1.2 Contactor firm shall also protect and fully indemnify AAI from any claims from Contractor firm's workmen/ employees, their heirs, dependents, representatives, etc. or from any other person(s) or bodies/ companies, etc. for any act of commission or omission while executing the order.
- 1.3 Contractor firm shall be responsible for compliance with all requirements under the laws and shall protect and indemnify AAI completely from any claims/ penalties arising out of any infringements by Contractor firm or its workmen/ employees.

6. Documentation & Training

Two set each of soft copy and hard copy of Installation, Operations including theory of operation, Technical Manual, Maintenance manual; Troubleshooting of the system, procedure for loading of the system and application software, etc. shall be supplied at site. The Operation, Technical and Maintenance manual will cover: -

- a. Details of each active and passive component, serial no., IP address, Login Id and Password, version reports, configuration reports, Detail Bill of Material, spares, acceleration Matrix to log a complaint etc.
- b. General technical description, Block Diagram, Schematic/ flow diagrams (I/O level), Drawing of Passive Cabling laid in the building shall be required.
- c. Preventive maintenance procedures & Support Escalation Matrix
- d. Fault analysis – schematic diagrams
- e. Technical & operation manuals with user Operation

Hybrid IP PBX with Redundant Server & SIP User Licenses		
Make:		Model:
S.No	Technical Specification	Compliance (Yes/No)
1	IP PBX system shall have redundant servers (two Server for redundancy from day 1 and should be in active - active configuration to support up to 25 IP,10 analog users and extendable up to 500 users/ Extensions. Redundant Server shall always be in sync such that the system should be able to switchover to other server in case of failure of one server with full capacity i.e. with 500 extensions/ users in real time w/o dropping on going calls. (The user /extensions figures are given tentatively.)	
2	IP PBX software should be compatible with the Server provided.	
3	Both the servers should be commercial grade server with minimum specification should be Intel Xeon Quad Core with 16 GB RAM and minimum 1 TB SSD or better.	
4	The system should be based on pure server-gateway architecture running on Linux /Unix OS supporting Analog, IP Desk Phone (SIP) in any combination, IP Phone, Video IP Phone, wireless IP phone (802.a/b/g/n) and Soft Phone, multimedia PCs, 3rd party SIP phones etc.	
5	IP extension: Loaded with 25 IP Phone Licenses from day 1 and IP phone licenses (SIP) should be universal i.e. can be used with any other phone of same OEM or any third-party phone.	
6	Gateway should have universal architecture with dual power supply, minimum two redundant Gigabit Ethernet Ports. Gateway Should support at least 32 nos of analog extension & 100 SIP extensions from day one. Gateway further expandable up to 256 Analog user's w/o adding any extra hardware or software's or license.	
7	Gateway should support E1-PRI, SIP trunk, CO Trunk Interface Ports and FXS Ports.	
8	It Should have minimum 02 Analog Trunk Lines expandable to 08 trunk Lines.	
9	It Should have minimum 02 nos of SIP trunk port to support SIP trunk lines and support up to 256 SIP trunk channels per Primary /Secondary server at single site.	
10	It should have Digital Primary Rate Interface (PRI) Line: 01 Nos. Additional 1 spare gateway for PRI and TDM connectivity needs to be considered day 1	

11	Gateway should support self-survival mechanism in case of failure of WAN/LAN Link w/o dropping on going calls.	
12	No card-based systems, only server-gateway architecture-based systems will be acceptable.	
13	All the users to be managed in a single database, which is managed centrally, multiple databases & bundling of Telephony system will not consider to meet Specification & scalability.	
14	It should have 16 Party Audio Conference bridge with multiple conferences with variable number of users should be possible within each of the conferencing from day 1.	
15	Support Ad-Hoc & Meet-Me audio conferencing from day 1.	
16	Support sending emails to all the participants giving them the conferencing details including PIN based security and scheduling.	
17	It should have integrated Voice Mail features for all users, Voice mail system should be of same OEM which should support Mail Boxes for all users, should have at least two gigabit Ethernet interfaces for easy connectivity to the network, should support G.711 and G.729 Codecs, Multi-level IVR functionality should be available.	
18	The Voice Mail provided by the vendor should be based on industry standard server. Card based or 3rd party Voice Mail solution are not Acceptable/Disqualified	
19	System should support standards-based CTI integration with 3rd party applications. System should support built-in IPSEC based VPN connectivity	
20	System should support built-in Remote access server (RAS) functionality	
21	System should support Diffserv for QoS (Quality of service) for the voice packets traveling over data networks.	
22	The IP PBX server should offer BHCC (Busy Hour Call Completion) of at least 25000 per server to ensure superior traffic handling capacities.	
23	The system should manage CAC (Call Admission Control) mechanisms to optimize the usage of the bandwidth in the WAN for multi-site configurations.	
24	The System should support LDAP (Local Directory Access Protocol), and following protocols: ML-PPP (Multilink Point-to-point Protocol), PAP (Password Authentication Protocol), CHAP (encrypted password)	

25	The system should support standards-based multi-site networking, using QSIG, SIP trunks or advanced networking, to interoperate with other PABX's, allowing feature transparency.	
26	The system should support Voice CODEC support G.711, G.729, G.729a & G.722 or any less utilization bandwidth across WAN and LAN, Video CODEC: H.264 or Equal.	
27	System should support UC functionality with 10 users (desktop/Laptop & Smart Phone) from day-1 and can be added if required in future without any modification to hardware.	
28	Unified Communications (UC) client should provide users with real time, collaboration capabilities	
29	Support for Windows and Mac OS, Support for Android and iOS devices Smartphones and The Unified communication client on softphone should provide full call control from an iPhone or Android powered smartphone. Should have all call control features like Call Transfer, Call Pickup, call forward, call park, Multiparty conference, Video Conference, Chatting, File sharing, FAX, Voicemail, Presence, BLF, DSS, Call History, Favorite etc.	
30	UC user can use Audio conference at least 6 party.	
31	System should provide call control, mobility, IM and presence, and Messaging, centralized licensing in a single server.	
32	System should support recordable Hold on Music, it should support multiple files.	
33	Allows a user's calls to be presented to both their current extension and to another number (personal mobile number) from day-1.	
34	Support point to point video calls from day-1 from same OEM Hard Video phone and Softphone.	
35	Call administration features: Operator, Dial Emergency, DID/DOD (Direct Inward/ Outward Dialing}, Call Forwarding, Call Hold, DND, Distinctive and Personalized Ringing, Alternate Routing, Fax on demand integration etc.	
36	Flexible numbering plan - Support up-to 2-10 Digit for an extension number and allow phone number assigned to a station to a station to be changed through software.	
37	Authorization Codes - 5-7-digit authorization code to make outgoing toll calls for ensuring no misuse of the system.	
38	CU (Caller Line Identification) facility (CLIP/CUR) - Calling Numbers (internal & external) should be displayed on all Analog extensions (FSK support phone).	

39	IP PBX shall have call recording with storage for 30 days.	
40	Support Mobility feature like Users can make and receive calls from any office as if using the phone on their own desk. Users have access to the centralized system and personal directory as well as their call logs (available on Analog and IP phones)	
41	The system should support complete encryption capabilities with the ability to encrypt all traffic (media and call control signaling) between IP phones, soft phones, call controllers, gateways and all other associated endpoints using a strong encryption algorithm like IPSec and SRTP.	
42	IP Phones should not support direct, external initiated, connections via HTTP, telnet, FTP, TFTP or any other protocol as means to prevent distributed Denial of Service attack exploitation, except those required for routine firmware upgrades.	
43	System should support SNMP based network management system to monitor all respected devices in communication network.	
44	The system to capable of supporting IPv4 and IPv6 IP addressing from days 1, System should have in built-in DHCP Server, which should be able to give IP Addresses to the endpoints.	
45	The equipment quoted by bidder must be SIP compliant.	
46	The offered system should have a valid TEC-GR approval certificate of server gateway system. TEC-GR approval certificate to interface with the public switch network should be enclosed along with the offer.	
47	The IP PBX should be capable of maintaining guaranteed performance when operating in continuously for 24 Hours a day for 365 Days.	
48	The IP PBX should have minimum warranty of 5 Years and should be the shelf-life of at least 6 years from the date of SAT.	
49	The IP PBX System shall be properly earthed.	
50	RoHS (Reduction of hazardous substance) compliance	
51	Declaration of Conformity (DoC) for EMC compliance	
52	Safety Declaration as per EN 62368-1, IEC 60950-1 & IEC 62368-1 compliance	

SITC of IP PHONES

S.No.	Generic Requirements
	Approved Make: Same as IPPBX
1.	Shall be on standard SIP protocol
2.	Shall have 10/100 connection, Echo canceling for local echo (AEC) half/ full duplex with auto negotiation and configuration along with Integrated Ethernet Switch for PC connection
3.	Shall support Voice compression standards G711, G722, G729a
4.	Shall support Power over Ethernet (PoE, IEEE 802.af)
5.	Shall have Fixed function keys for Settings, Messages
6.	Shall have Free programmable keys with status indication on the LCD display
7.	Shall have Pre-programmed keys for Call Log Contacts, call forwarding, Redial.
8.	Shall store local call log with 30 or more entries for each category (dialed, received, missed, forwarded calls)
9.	Shall support IEEE802.1Q for VLAN tagging and prioritization. VLAN ID configuration options: <ul style="list-style-type: none"> • Manual/ Management Application • DHCP Option 43 • LLDP-MED
10.	Shall support the following Security Protocols and features
11.	Signaling Encryption (TLS), RFC5746: TLS Renegotiation Indication Extension, Payload Encryption (SRTP, DTLS-SRTP), IEEE 802.1x supplicant (EAP-TLS und PEAP)

Note-

There will be no preferred make list in respect of Airport system work. The item of any make and model, meeting the technical specs as per technical specification mentioned in tender on part of Airport system will be accepted.

If any such condition appears in tender document for Airport system work, then same will be super shaded by above condition to avoid ambiguity.

Technical Specifications for Active IT Components

Item no. 1 - Next generation Firewall (HA Mode)	
S. No	Generic Requirements
1	The appliance-based security platform should be capable of providing minimum Threat Prevention throughput of 1 Gbps or higher (2 Gbps in case higher traffic requirement) on real world /Ent <i>Mix</i> /App Mix traffic after enabling IPS, User ID, Anti-Virus, logging and Application Visibility security services in a single appliance from day one.
2	The Firewall should support Advanced Threat Protection like malware and zero-day threats with AI-based malware detection that do not yet have known signatures.
3	The appliance should have minimum 4x 1Gig TX,8x10G SFP+ Ports, OOB, Console, 2x HA and USB from day-1. The trans receiver has to be proposed as per solution. The Appliance should have redundant internal power supply and fan.
4	The Firewall should have Application visibility and control/ AVC from Day 1.
6	The proposed firewall shall have built-in high availability (HA) features without extra cost/license or hardware component. High availability configurations should support Active/Active or Active/ Passive.
	Should support up to 1.5 Million or higher Concurrent sessions and at least 90000 or higher new sessions per second
8	Firewall should support at-least 1500 or higher users limit.
9	Firewall should provide State-full fail over. HA configuration that uses dedicated HA/ control interface apart from the mentioned traffic interfaces
10	System Throughput Should provide 4Gbps (8 Gbps in case higher traffic requirement) or higher Firewall Throughput Should provide 2 Gbps (4 Gbps in case higher traffic requirement) or higher IPSec VPN throughput on <i>real</i> / world (Large Packet) Should provide 1.5 Gbps (3 Gbps in case higher traffic requirement) or higher IPS throughput. Should provide 1 Gbps (2 Gbps in case higher traffic requirement) or higher Threat Protection throughput (Firewall, Application Security/ AVC and IPS
11	Memory —at-least 8GB or higher and minimum 120 GB storage/ SSD
12	Support: - IKEv1 and v2, IPSec VPN standards, 56-bit DES, 168-bit 3DES, 256-bit AES encryption
13	Proposed solution must support Load Balancing/Load sharing of ISP Links.
14	Authentication, Authorization and Accounting (AAA) support: RADIUS or TACACS+
15	Support for: Network and application level attacks ranging from malformed packet attacks to DoS attacks, Support RSA and Diffie-Hellman, MD-5, SHA-1, SHA-128, SHA-256
16	Firewall should support static Routes, OSPFv2, OSPFv3 and BGP, PIM Multicast routing

17	The proposed NGFW should be native Layer 7 and the device should be able to handle Management functions like configuration, reporting and route update, Signature matching (like exploits, virus, spyware, CCP), Security processing (like apps, users, content/URL, policy match, SSL decryption, app decoding etc) & Network Processing (like flow control, route lookup, MAC lookup, QoS, NAT etc).
18	<p>Management</p> <p>Web based management to support for remote monitoring through firewall manager</p> <p>Accessible through variety of methods including: Telnet, Console Port, SSH Dedicated Out-of-Management interface Support SNMPv1, v2, v3 & Support for syslog</p>
19	The proposed firewall should have integrated Web Content Filtering solution without external solution, devices or hardware modules.
20	The proposed solution should support Data Loss Prevention (DLP) which allows administrators to prevent sensitive data from leaving the network. Administrators should be able to define sensitive data patterns and data matching these patterns that will be blocked and/or logged when passing through the device.
21	The Solution should be supplied with complete installation, configuration, and training by OEM /OEM certified technical staff.
22	The Firewall solution should support NAT46, NAT64,NAT66 DNS64 & DHCPv6
23	Implementation and integration of the proposed solution with the existing network infrastructure and configuring / setting up AAA / Directory Services and / or any other prerequisite application / package / service is also the responsibility of the Vendor (SI).
24	The proposed firewall should be certified by MTCTE in reference to Gol. Any Original Equipment Manufacturer (OEM)/ importer/ dealer who wishes to sell, import, or use any telecom equipment in India, shall have to obtain Certificate from Telecommunication Engineering Centre TEC (Telecommunication Engineering Centre).
25	Firewall should be tested and certified for EAL 3/NDPP or above under Common Criteria Certification for security related functions or under Indian Common Criteria Certification Scheme (IC3S).
26	The proposed firewall should have 2 years warranty with NBD support (back-to-back from OEM)

Item No. 2 - Core cum Distribution Switch-(HA Mode)	
S. No	Generic Requirements
1	Switch should be with minimum 48/24 no. of 10 Gig SFP+ ports (as per requirement) and 4 nos. of 40/100 Gig QSFP ports from Day-one.
2	Switch should support for Active-Active High Availability or Virtual Chassis / Stacking.
3	Switch should have hot swap able 1:1 redundant internal power supply.

4	Switching system shall have minimum 32K MAC Addresses and 1K active VLANs.
5	Switch should support minimum 1500 ACLs, minimum 4K Multicast routes, minimum 20K Unicast Routes for IPv4 and 10K Unicast Routes for IPv6.
6	Should support IEEE Standards of Ethernet: IEEE 802.1D, 802.1s, 802.1w, 802.1x, 802.3ad, 802.3x, 802.1p, 802.1Q
7	Should have static routing, OSPF, OSPFv3, BGP, HSRP for IPv6/VRRPv3, VRF (Virtual routing and forwarding), IGMP v2/v3 and PIM multicast routing, VXLAN, Policy based routing.
8	Shall have 802.1p class of service, classification, policing/shaping. Should support strict priority queuing
9	Switch should support management features like SSHv2, SNMPv2, SNMPv3, NTP, RADIUS OR TACACS+,
10	Switch should support port security, DHCP snooping, Dynamic ARP inspection, IP Source guard, BPDU Guard, Spanning tree root guard.
11	Switch should have IPv6 security features from Day-1.
12	Should support 802.1x authentication and accounting, IPv4 and IPv6 ACLs and Dynamic VLAN assignment. Switch should support MACSEC /GRE. Switch should support control plane policing to protect switch CPU from DoS attack.
13	Switch should support Weighted Round Robin (WRR) Deficit Weighted Round Robin (WDRR) scheduling or equivalent and Weighted Tail Drop (WTD)/Weighted Random Early Detection (WRED) or equivalent congestion avoidance.
14	Switch shall support application visibility/insight and traffic monitoring using-net Flow/s flow/j flow entries.
15	Switch shall conform to UL 60950 or IEC 60950/62368-1 or CSA 60950 or EN 60950/62368-1 Standards for Safety requirements of Information Technology Equipment.
16	Switch shall conform to EN 55032 Class A/B or CISPR22 Class A/B or CE Class A/B or FCC Class A/B Standards for EMC (Electro Magnetic Compatibility) requirements.
17	Switch/Switch Series should be tested and certified for EAL 2/NDPP/FIPS 140-2 or above under Common Criteria Certification or under Indian Common Criteria Certification Scheme (IC3S).
18	The proposed switch should be certified by MTCTE in reference to Gol. Any Original Equipment Manufacturer (OEM)/ importer/ dealer who wishes to sell, import, or use any telecom equipment in India, shall have to obtain Certificate from Telecommunication Engineering Centre TEC (Telecommunication Engineering Center).
19	Switch/ Switch Series should have Ipv6 Certified/IPv6 ready from Day-1.
20	Switch should support Operating Temperature Range of 0°C to +40°C. $\pm 5^\circ\text{C}$ Temp variation on lower and higher side is acceptable.
21	The proposed switch should have minimum 16 GB RAM, 16 GB Flash and 32 MB packet buffer.
22	Switch shall have event and system history logging functions. The switch shall generate system alarms on events. Facility to put selective logging of events onto a separate hardware where the analysis of log shall be available.
23	Switch should have Trusted Platform Module (TPM)/ Secure Boot Functionality.

24	Switch should have 2 years warranty with NBD support (back to back from OEM).
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Item No 3 - 48 Port Non PoE Access Switch	
S. No	Generic Requirements
1	Each proposed switch should be 1RU and must have 48 ports with 10/100/1000 Base-T and 4 SFP+ uplink ports available from Day1.
2	Switch should be populated with 2 Single Mode 10G SFP+ Modules from Day 1.
3	Each proposed switch must support stacking for up to 8 switches or better stacking solution.
4	Switch should have minimum 1 GB DRAM, minimum 2GB Flash and minimum 6 MB packet buffer.
5	Shall have minimum 16K MAC Addresses and minimum 512 active VLANs.
6	Switch should have L3 functionalities like static routing and shall support RIP, PIM, OSPF, PBR & QoS features. Switch should have capability to support VXLAN from Day1.
7	Switch should support Weighted Round Robin (WRR) / Deficit Weighted Round Robin (DWRR) scheduling or equivalent and Weighted Tail Drop (WTD)/ Weighted Random Early Detection (WRED) or equivalent congestion avoidance.
8	Switch should have 802.1p class of service and 802.1Q VLAN tagging.
9	Switch should have IPv6 security features to protect against IPv6 spoofing attack. Switch should support MACSEC/GRE.
10	Switch should have Trusted Platform Module (TPM)/Secure Boot functionality.
11	Switch should support control plane policing or equivalent to protect switch CPU from DOS attack
12	Should support 802.1x authentication and accounting, ACLs and VLAN assignment
13	Switch shall support application visibility/ insight and traffic monitoring using net Flow/ s flow/j flow entries.
14	Switch should be tested and certified for EAL 3/NDPP or above under Common Criteria Certification/Indian common criteria certification scheme (IC3S).
15	Switch should support DHCP, Auto Negotiation, LACP, UDLD, MDIX, GVRPVTP, TFTP, NTP, Per-port broadcast, multicast, Static routing, Layer 2 trace route or IPv4 and IPv6 trace route and unicast storm control.
16	Switch/Switch Series should be IPv6 Certified/IPv6 ready from Day-1.
17	Switch should have 2 years warranty with NBD support (back-to-back from OEM).
18	The proposed switch should be certified by MTCTE in reference to Gol. Any Original Equipment Manufacturer (OEM)/ importer/ dealer who wishes to sell, import, or use any telecom equipment in India, shall have to obtain Certificate from Telecommunication Engineering Centre TEC (Telecommunication Engineering Center).

Item No. 4 - Access Switch: 24 Port PoE+	
S. No	Generic Requirements
1	Each proposed switch should be 1RU and must have 24 Nos. 10/100/1000 Base-T Ports and 4 Nos. SFP+ uplink ports available from Day1.
2	Switch should be with PoE+ capability and should have min 370W or above PoE Power.
3	Switch should be populated with 2 Single Mode 10G SFP+ Modules from Day 1.
4	Each proposed switch must support stacking for up to 8 switches and better stacking solution.
5	Switch should have field replaceable Redundant Power Supply from Day 1.
6	Switch should have minimum 1 GB DRAM , minimum 2GB Flash and minimum 6 MB packet buffer.
7	Shall have minimum 16K MAC Addresses and minimum 512 active VLANs.
8	Switch should have L3 functionality like static routing and shall support RIP, PIM, OSPF, PBR & QoS features. Switch should have capability to support VxLAN for future requirements from Day 1.
9	Switch should have 802.1p class of service and 802.1Q VLAN tagging.
10	Switch should have IPv6 security features to protect against IPV6 spoofing attack. Switch should support MACSEC/GRE.
11	Switch should support DHCP, Auto Negotiation, LACP, UDLD, MDIX, GVRP/VTP, TFTP, NTP, Per-port broadcast, multicast, Static routing, Layer 2 trace route or IPv4 and IPv6 traceroute and unicast storm control.
12	Switch should support Weighted Round Robin (WRR)/ Weighted Deficit Round Robin (WDRR) scheduling or equivalent and Weighted Tail Drop (WTD)/ Weighted Random Early Detection (WRED) or equivalent congestion avoidance.
13	Switch should have Trusted Platform Module (TPM)/Secure Boot functionality.
14	Switch should support control plane policing or equivalent to protect switch CPU from DoS attack
15	Should support 802.1x authentication and accounting, ACLs and VLAN assignment.
16	Switch shall support application visibility/ Insight and traffic monitoring using net Flow/ s flown flow entries,
17	Switch should be tested and certified for EAL 3/NDPP or above under Common Criteria Certification/Indian common criteria certification scheme (IC3S).
18	Switch/Switch Series should be IPv6 Certified/IPv6 ready from Day1.
19	Switch should have 2 years warranty with NBD support (back-to-back from OEM).

20	The proposed switch should be certified by MTCTE in reference to Gol. Any Original Equipment Manufacturer (OEM)/ importer/ dealer who wishes to sell, import, or use any telecom equipment in India, shall have to obtain Certificate from Telecommunication Engineering Centre TEC (Telecommunication Engineering Center).
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Item No. 5 - Access Switch: 24 Port non PoE	
S. No	Generic Requirements
1	Each proposed switch should be 1RU and must have 24 ports with 10/100/1000 Base-T and 2 SFP+ uplink ports available from Day 1
2	Switch should have slot/ports for stacking with stacking ports and cables and better stacking solution.
3	Switch should have minimum 1 GB DRAM , minimum 2GB internal/external Flash and minimum 6 MB packet buffer.
4	Shall have minimum 16K MAC Addresses and 512 active VLANs.
5	Switch must have L3 functionality like static routing, RIP, PIM, OSPF, PBR & QoS features from Day 1. Shall have 802.1p class of service, classification, policing /shaping. Switch should have capability to support VXLAN for future requirements from Day 1.
6	Switch should have IPv6 security features. Switch should support MACSEC/GRE. Switch should support control plane policing to protect switch CPU from DoS attack
7	Should support 802.1x authentication and accounting, ACLs and VLAN assignment.
8	Switch shall support application visibility/ insight and traffic monitoring using net Flow/ s flow/ j flow entries.
9	Switch should be tested and certified for EAL 3/NDPP or above under Common Criteria Certification/Indian common criteria certification scheme (1C3S).
10	Switch/ Switch Series should have IPv6 Certified/IPv6 ready from Day-1.
11	Switch should support Operating Temperature Range of 0°C to +40°C. $\pm 5^{\circ}\text{C}$ Temp variation on lower and higher side is acceptable.
12	Switch should support DHCP, Auto Negotiation, LACP, UDLD, MDIX, GVRP/VTP, TFTP, NTP, Per-port broadcast, multicast, Static routing, Layer 2_ trace route or IPv4 and IPv6 trace route and uni-cast storm control.
13	Switch should support Weighted Round Robin (WRR) / Deficit Weighted Round Robin (DWRR) scheduling and Weighted Tail Drop (WTD)/ Weighted Random Early Detection (WRED) or equivalent congestion avoidance.
14	Switch should have Trusted Platform Module (TPM)/Secure Boot functionality.

15	The proposed switch should be certified by MTCTE in reference to Gol. Any Original Equipment Manufacturer (OEM)/ importer/ dealer who wishes to sell, import, or use any telecom equipment in India, shall have to obtain Certificate from Telecommunication Engineering Centre TEC (Telecommunication Engineering Center).
16	Switch should have 2 years warranty with NBD support (back-to-back from OEM).

Item No. 6 - Access Switch: 48 Port PoE+	
S. No	Generic Requirements
1	Each proposed switch should be 1RU and must have 48 Nos. 10/100/1000 Base-T Ports and 4 Nos. SFP+ uplink ports available from Day 1 with PoE+ capability.
2	Switch should have slot/ports for stacking with stacking ports and better stacking solution.
3	Switch should be with PoE+ capability and should have min 740W or better PoE Power.
4	Switch should have internal redundant power supply.
5	Switch should have minimum 1 GB DRAM , minimum 2GB Internal/external Flash and minimum 6 MB packet buffer.
6	Shall have minimum 16K MAC Addresses and 512 active VLANs.
7	Switch must have L3 functionality like static routing, RIP, PIM, OSPF, PBR & QoS features from Day 1. Shall have 802.1p class of service, classification, policing /shaping. Switch should have capability to support VXLAN for future requirements from Day 1.
8	Switch should support Weighted Round Robin (WRR) / Deficit Weighted Round Robin (DWRR) scheduling and Weighted Tail Drop (WTD)/ Weighted Random Early Detection (WRED) or equivalent congestion avoidance.
9	Switch should have IPv6 security features. Switch should support MACSEC/GRE. Switch should support control plane policing to protect switch CPU from DoS attack
10	Should support 802.1x authentication and accounting,, ACLs and VLAN assignment.
11	Switch shall support application visibility and traffic monitoring using net Flow/ s flow/ j flow entries.
12	Switch should be tested and certified for EAL 3/NDPP or above under Common Criteria Certification/Indian common criteria certification scheme (IC3S).
13	Switch/ Switch Series should have Ipv6 Certified/IPv6 ready from Day-1.
14	Switch should support Operating Temperature Range of 0°C to +40°C. $\pm 5^{\circ}\text{C}$ Temp variation on lower and higher side is acceptable.
15	Switch should support DHCP, Auto Negotiation, LACP, UDLD, MDIX, GVRP/VTP, TFTP, NTP, Per-port broadcast, multicast, Static routing, Layer 2 trace route or IPv4 and IPv6 traceroute and unicast storm control.
16	Switch should have Trusted Platform Module (TPM)/Secure Boot functionality.

17	The proposed switch should be certified by MTCTE in reference to GoI. Any Original Equipment Manufacturer (OEM)/ importer/ dealer who wishes to sell, import, or use any telecom equipment in India, shall have to obtain Certificate from Telecommunication Engineering Centre TEC (Telecommunication Engineering Center).
18	Switch should have 2 years warranty with NBD support (back-to-back from OEM).

Item No. 7 - Access Switch: 8 Port Industrial Grade PoE+	
S. No	Generic Requirements
1	The proposed switch should be 1U 19" Rack Mountable and must have 8 Nos. 10/100/1000 Base-T Ports and 2 Nos. 100/1G/10G SFP+ uplink ports available from Day 1 with PoE+ capability.
2	It should have the capability to monitor Uni-directional Link Detection (UDLD) and prevent loops if unidirectional traffic is detected.
3	Switch should be with PoE+ capability and should have 4 ports of Class 6 PoE(60W) and 4 ports of Class 4 PoE(30W). It should have fixed power supply/DIN RAIL and fanless.
4	The Switch should support new UHD IP cameras, Wi-Fi access points, and future-ready Gigabit speed automation devices from Day-1.
5	Switch should have minimum 4 GB DRAM, minimum 1GB eMMC/Flash memory
6	Shall have minimum 16K MAC Addresses and 256 active VLANs.
7	Switch must have L3 functionality like static routing, RIP, PIM, OSPF, PBR & QoS features from Day1. Shall have 802.1p class of service, classification, policing /shaping
8	The switch should support IEEE 802.3az Energy Efficient Ethernet and PoE allocation by usage or class, with LLDP and LLCP-MED
9	Switch should have IPv6 security features. Switch should support MACSEC/GRE. Switch should support control plane policing to protect switch CPU from DoS attack, CPU protection. STP BDU port protection, STP root guard, traffic prioritization for real time classification.
10	Should support 802.1x authentication and accounting, ACLs and VLAN assignment
11	Switch shall support application visibility and traffic monitoring using net Flow/ s flow/ j flow entries.
12	Switch should be tested and certified for EAL 3/NDPP or above under Common Criteria Certification/Indian common criteria certification scheme (IC3S). Additionally, it should be complied for IEC 60068-2-27, IEC 60068-2-6.
13	Switch/ Switch Series should have Ipv6 Certified/IPv6 ready from Day-1.
14	Switch should support Operating Temperature Range of -40°C to +70°C. * 5°C Temp variation on lower and higher side is acceptable.

15	Switch should support DHCP, Auto Negotiation, LACP, UDLD, MDIX, GVRP/VTP, TFTP, NTP, Per-port broadcast, multicast, Static routing, Layer 2 trace route or IPv4 and IPv6 traceroute and unicast storm control.
16	It should extend geographical stability for longer distances coverage. It should support IP30 for protection from tools and wires greater than 2.5 mm. It should have protection against the corrosion (IEC60068-2-52)salt fog and (IEC 60068-2-60) mixed gas.
17	Switch should have Trusted Platform Module (TPM)/Secure Boot functionality.
18	The proposed switch should be certified by MTCTE in reference to Gol. Any Original Equipment Manufacturer (OEM)/ importer/ dealer who wishes to sell, import, or use any telecom equipment in India, shall have to obtain Certificate from Telecommunication Engineering Centre TEC (Telecommunication Engineering Center).
19	Switch should have 2 years warranty with NBD support (back-to-back from OEM).

Item No. 8 - WIRELESS LAN CONTROLLER/MANAGER (HA Mode)	
S. No	Generic Requirements
1	Solution must be compliant with IEEE CAPWAP/LWAPP/IITPS/VxLAN/IPSEC/EoGRE or equivalent standard.
2	All required licenses as per site requirement & mentioned specifications of complete solution to achieve the functionality should be provided from day 1. Device should be scalable to minimum 250 AP in same hardware and minimum 5000 clients.
3	Device must have at least 2x10G SFP+ and 2x 1G copper interfaces.
4	Controller should have console port, 1 x RJ45 OOB, USB port
5	Device Must support an ability to dynamically adjust channel and power settings based on the RF environment
6	The device should provide latest network authentication (WEP, WPA, WPA2) and encryption types like DES/3DES, TKIP and AES.
7	The device should provide air-time fairness between different speed clients — slower clients should not be starved by the faster clients and faster clients should not adversely affected by slower clients.
8	Device should support L2 and L3 roaming of IPv6 clients
9	The device should have ability to map SSID to VLAN and dynamic VLAN support for same SSID.
10	The device should support automatic channel selection for interference avoidance.
11	Must support coverage hole detection and correction that can be adjusted on a per WLAN basis.
12	Device must be MTCTE Certified as per Telecommunication Engineering Centre (TEC). Certificate to be enclosed.
13	Device should support IPv6 functionality from Day1.

14	Device should support client IPv6 from Day 1.
15	Device Should adhere to the strictest level of security standards, including 802.11i, WPA3, WPA2, WPA, 802.1X with multiple Extensible Authentication Protocol (EAP)
16	The device should detect and protect if a client/tool try to flood an AP with 802.11 management frames like authenticate/associate frames which are designed to fill up the association table of an AP.
17	Device should have rogue AP detection, classification, and automatic containment feature. It should automatically blacklist/protect clients when it attempts any attack.
18	Device should be able to detect attacks like Broadcast de-authentication / NULL probe from day one for all access points
19	Device Must support 802.11e and WMM
20	Device should have role based access for Data, Voice and Video Call Admission and Stream prioritization for preferential QoS. It should support session prioritization.
21	Device should have per client rate limit on same SSID.
22	Should have External Captive Portal Integration - Web-services based API for external web-portals to integrate with the controller.
23	The device must support L7 DPI based Application based visibility, QoS and controlling capability.
24	WLC should be able to provide a web-based application that allows non- technical staff to create Guest accounts with validity for fixed duration like hours or days.
25	WLC should be have administration access through HTTPS GUI, SSH CLI. Administrative users should have account security features such as session idle timer, account Lockout, password expiration, password reuse, two factor authentication. Should have option to enable captcha to make sure a human is logging into the system
26	Device should be quoted with 2 years warranty with NBD support (back to back from OEM).

Item No. 9: Access Points (Indoor)	
S. No	Generic Requirements
1	Access Points proposed should have minimum 4x4:4 MIMO radios on both 2.4 GHz and 5 GHz antennas for transmission and receiving with minimum 3 Gbps or higher aggregate data rate. It should support MU-MIMO and OFDMA for increased and efficient connectivity from Day1.
2	Mounting kit should be standard from OEM directly.
3	Access Points should have dynamic bandwidth adjustments to accommodate fluctuating device density, enhanced roaming facilitated by an equitable distribution of Effective Isotropic Radiated Power (EIRP) to radios and real-time channel assignments to minimize co-channel interference.
4	Access points must support BPSK, QPSK, 16-QAM, 64-QAM, 256 QAM, 1024 QAM modulation types.
5	Must support 21 dBm or more of transmit power in both 2.4Ghz and 5Ghz radios.
6	Must have 1 nos. or more of multi gigabit Ethernet (RJ-45) 100M/1G/2.5G- IEEE 802.3bz supporting POE/POE+.
7	Must have minimum 16 SSIDs.

8	AP should be manageable from cloud/virtual WLC in future if required or without a controller wherever required.
10	The Access points should be Centrally Managed by a full-fledged controller.
11	In some small, isolated environments, the AP should be able to function as a full-fledged standalone access point without the requirement of a controller.
12	AP Should support detecting wireless interferences and should have advanced mechanism to minimize the impact of interference from cellular networks, Distributed antenna systems (DAS) etc.
13	AP should support AI powered analytics for client health, air time utilization, Access Point details and more.
14	AP Should support Radio resource management for optimum wireless
15	Must operate as a sensor for wireless IPS.
16	Must support WPA-PSK, WPA-TKIP, WPA2 AES, WPA3, WIDS/WIPS.
18	AP must have in-built IOT with ZigBee/ BLE(Bluetooth Low Energy).
19	Must be plenum-rated (UL2043) or equivalent.
20	AP must have Wi-Fi 6 Certified. Wi-Fi certificate to be enclosed.
21	AP should be quoted with 2 years warranty With NBD support (back-to-back from OEM).
22	AP should support IEEE 802.11 a/b/g/n/ac/ax. AP should support 802.1q VLAN tagging.
23	AP should support Authentication via 802.1X and Active Directory
24	Device must be MTCTE Certified as per Telecommunication Engineering Centre (TEC). A certificate should be submitted for compliance.

Technical Specification for Passive IT Components

S. No	Item	Generic Specification
1	Cat6A UTP Cable	<p>4-pair, Cat 6A UTP Cable, LSZH, Channel performance up to 500 MHz or more, ETL 4 connector performance channel test report as per ISO/IEC 11801 23 AWG bare solid copper, Meets EIA/TIA 568-C.2/ANSI/T1A 568.2D. RoHS Compliant/EN 50575. Cable Skew: ≤ 45 nsec/100 meters, Characteristic Impedance: $100 \pm 6 \Omega$ @ 1-500 MHz DC Resistance Max: 9.5 Ohms/100m, IEC 60332-3/60332-1, IEC 61034-2, IEC 60754-2, ISO/IEC 11801/EN 50173, Operational Temp: -20deg C to 60deg C</p>
2	Cat6A Patch Panel 24 Port(Loaded)	<p>Cat 6A U/UTP 24-port Jack Panel loaded with 24 nos. UTP ports for PCB based IO Jacks, 1U size, ISO/IEC 11801/EN50173 EIA/TIA 568-C.2/ TIA-568 2.D, UL Listed, RoHS Compliant, Current Rating: 1.5A @20°C or 68°F</p>
3	Cat6A Patch Cords for 3 feet and 7 feet both	<p>3 Feet (at Rack end) and 7 Feet (at User End) Cat 6A U/UTP Patch Cable, TIA- 568C/ TIA-568 2.D Category- 6A, UL-listed/ETL, RoHS, solid copper, Plug Insertion life Min. 750 times, LSZH, IEC 60332-3/ IEC 60332-3-22, IEC 60754-2/ IEC 60754, IEC 61034-2/ IEC 61034/ ISO/IEC 11801/EN 50173 Operational Temp: -20° to 60° Celsius</p>
4	Cat 6A UTP I/O	<p>Cat 6A UTP Jack PCB based Information Outlet (I/O) RJ45, TIA-568 C.2/T1A-568 2.0 Contact Resistance: maximum 100milli ohms; Insulating resistance minimum 500 milli ohms; Current Rating: 1.5 A (max), Meets and exceeds ISO/IEC 11801/EN 50173, EIA/TIA 568-C.2/ TIA-568 2.D ROHS compliant</p>
5	Cat6A Face Plate	<p>Single Port/Dual Port Face Plate of Size 3x3, Material should be ABS/UL 94 V-0 with spring shutter on plate or Jack, Face plate shall accept all modules for UTP, fibre optic and audio/video application,</p>
6	Cat6A Gang Box	<p>Gang Box to be supplied should be ISI approved.</p>

7	Fiber Optic Cable Single Mode	<p>Single Mode Optical Fiber 6/12 core, Uni-Tube/Multi-Tube, 9/125μm, OS2 Type, Corrugated Steel Tape Armoured (STA), Polyethylene (HDPE) outer, LSZH and RoHS Complaint, Telecordia GR-20, B1.3 and ITU T G652.D, ISO/IEC 11801, IEC-60793-1, 60793-2, EN50173, ANSI/TIA 568-C.3, Tensile Strength: 1500 N or better. Maximum Crush Resistance should be 2000N/10 cm or better. Max. Attenuation at 1310 nm: 0.34 dB/km and at 1550 nm: 0.22 dB/km. The product supplied should be OEM performance warranty of 20 years or more.</p>
8	12 Core Loaded LIU LC type SM	<p>12F for 12 core, 1U LC Style, Loaded with SM pigtails and Splice Tray & Couplers & Splice Protectors, Metal/Alloy housing, Telecordia GR-20 Pigtail should comply G.657.A1 (Bend Insensitive), LSZH and RoHS compliant, ANSI/TIA 568-C.3, Optical performance of pigtails: insertion loss max: 0.34 dB and return loss minimum: 50 dB. The product supplied should be OEM performance warranty of 20 years or more</p>

9	24 Core Loaded LIU LC type SM	<p>24F for 24 core, 1U LC Style, Loaded with SM pigtails and Splice Tray & Couplers & Splice Protectors, Metal/Alloy housing, Telecordia GR-20 Pigtail should comply G.657.A1 (Bend Insensitive), LSZH and RoHS compliant, ANSI/TIA 568-C.3, Optical performance of pigtails: insertion loss max: 0.34 dB and return loss minimum: 50 dB. The product supplied should be OEM performance warranty of 20 years or more.</p>
10	48 Core Loaded UU LC type SM	<p>48F for 48 core, 1U LC Style, Loaded with SM pigtails and Splice Tray & Couplers & Splice Protectors, Metal/Alloy housing, Telecordia GR-20 Pigtail should comply G.657.A1 (Bend Insensitive), LSZH and RoHS compliant ANSI/TIA 568-C3, Optical performance of pigtails: insertion loss max: 0.34 dB and return loss minimum: 50 dB. The product supplied should be OEM performance warranty of 20 years or more.</p>

11	LC-LC SM Patch Cords Duplex 3 Mtr.	<p>Bend Insensitive, LSZH and RoHS compliant, IEC 60332-3-22/60332-3-1, IEC 60754-2/IEC 60754-20, Duplex patch chord LC-LC connector on both ends, ANS/ICEA S-83-596/TIA/EIA-492 and Telecordia GR-409 and ANSI/TIA-568-C.3/568-D.3.</p> <p>The product supplied should be OEM performance warranty of 20 years or more.</p>
12	Cable Manager	The product supplied should be in compliance with the Rack.

Appendix – 1A

Specifications for Carrying out Soil Investigation for Building Works**1. GENERAL**

The soil consultant shall visit the site and shall carry out soil investigation as per the scope of work given below and shall submit the soil report as per the enclosed proforma.

2. OBJECTIVE

To decide safe & cost effective type of foundation, depth of foundation, load bearing capacity of soil, location of ground water and possible corrosive effects of soil and water on foundation material, ground improvement/soil treatment, if any, required before laying/casting of foundation.

In order to achieve the above objective, following engineering properties of the soil need to be evaluated:

- a. Soil type and its engineering properties.
- b. Depth of water table.
- c. Chemical properties of sub-soil and sub-soil water.
- d. Sub soil profile indicating thickness of various soil strata up to the depth as indicated in Table-1.

Sl.	Type of Building Structure	Depth of Bore Hole from existing Natural GL	Spacing of Bore Holes.	Minimum No. of Bore Holes 3Nos.	Remarks
I	II	III	IV	V	VI
1.	Operational Boundary Wall	3 to 4m	500m	3Nos.	
2.	Electric Sub-station	6 to 10m	--	3Nos.	
3.	Culverts	10m from Invert level of Culvert	30m	3Nos.	
4.	Underground Water Tanks, Fire Stations	10m	--	3Nos.	
5.	Residential Colony up to 4 Stories	10 to 15m	40 to 45m	3Nos.	

6.	a. Airport terminal, Cargo buildings where open foundation are anticipated:	15 to 20m	30 to 40m	5Nos.	
	i) Column spacing up to 10m.	20 to 25m	30 to 40m	5Nos.	
	ii) Column spacing more than 10m.				
	b. Airport terminal, Cargo building where Pile foundation are Anticipated.	30m to 40m	30m	5Nos.	
7.	Air Traffic Control Towers of Height 25 to 40m -	20 to 30m	--	1 Boreholes of 30m depth & 2 Boreholes of 20m depth	Also Plate Load Test to be conducted as per scope of work[Ref. clause 3(d)]

Note:

- a. Diameter of borehole should be 100mm.
- a. Borehole can be terminated at a shallower depth than that specified in column No.3 if hard strata is encountered or N value is more than 50.
- b. In case hard strata is encountered at a shallow depth say about 2.5m from the existing ground level, it is advisable to extend, minimum No. of bore holes as specified in column No.5, 3 to 7m into such strata.
- c. Spacing of bore holes can be reduced than that specified in column No.4, if large variation is encountered between successive bore holes.

3. SCOPE OF WORK

- a. No., spacing and depth of bore holes as per Table-1. The bore holes shall be located at possible location of column of building structure, heavily loaded RCC walls, in such a way so as to have a representative cross-section of soil profile for the area under investigation.
- b. Collection of disturbed/undisturbed samples shall be done at 0.75m, and there onwards at every 1.5m interval or change of strata whichever is earlier shall be taken.
- c. SPT tests — shall be carried out at 0.75m, 1.5m, 2.25m, 3m and there onward at every 1.5m interval or at change of strata, whichever is earlier.
- d. Modulus of sub-grade reaction — 1 No. Plate load tests (PLT) to be conducted at proposed foundation level for Air traffic control Tower.

- e. Particle size analysis of soil- to be conducted on all samples
- f. Triaxial Test- minimum 3No.tests per bore hole.
- g. Specific gravity test- minimum 5No.tests.
- h. Liquid limit, Plastic Limit, Plasticity Index, Swell Index, Shrinkage limit— to be conducted on all samples for clayey and swelling soils.
- i. In situ density, dry density, Natural moisture content of soil - to be conducted on all samples.
- j. Permeability tests- to be conducted on granular soils - minimum 3No.tests.
- k. Vane shear test — to be conducted on soft and sensitive clays- minimum 3 No. tests.
- l. Consolidation test - to be conducted on clayey soils— minimum 3 No. tests.
- m. Determination of organic material in soil by wet combustion- minimum 3No.tests.
- n. Determination of chlorides & sulphates, organic matter in soil- minimum 3No.tests.
- o. Moisture — density relation of soil — to be conducted on all samples.
- p. Chemical analysis of ground water indicating sulphates, chlorides, pH value - minimum 3No.tests.
- q. Recommendation of the consultant including soil stabilization/ground improvement, if required.
- r. In case rock is encountered at a depth less than or equal to 1.5m below the existing ground level, tests for soil as stipulated in scope of work need not be carried out. In that situation, following tests on rocks shall be carried out:
 - i. Probing shall be done to ascertain rock profile.
 - ii. RQD and rock mass rating.
 - iii. Visual examination
 - iv. Unit weight.
 - v. Water absorption.
 - vi. Porosity.
 - vii. Petro graphic analysis
 - viii. Compressive strength.
 - ix. Shear strength

All tests shall be carried out as per latest provisions in BIS code including all applicable official amendments and revisions. The consultant may use any other code in case there is no BIS code for a particular test.

4. Report shall include the following

- a. Introduction: (Please provide description of work).
- b. Site description : (Pl. give detailed description of site indicating levels w.r.t surrounding area including drainage. Whether the area under investigation is fairly level or have ups & downs or inclined etc.)
- c. Field Investigation: (Please provide summary of various tests carried out in the field).
- d. Field Investigation Photographs: (Please attach color Photograph showing the field test in progress along with the concerned technician / Engineer)
- e. Lab Investigation: (Please provide summary of various tests carried out in the lab).
- f. Location Map: (Please give Location map of the area under investigation indicating land marks which can clearly identify the area under investigation. Further the location plan should also indicate test locations viz. boreholes, plate load tests on a Well-Proportionate Scale).
- g. Longitudinal Section: (Pl. give longitudinal section of soil profile passing through various bore holes. The longitudinal section must indicate RL at location of bore hole, water table, soil specification etc. at each borehole).
- h. The Soil Profile: (Pl. give Detailed description of each layer/stratification of soil considering all the bore holes, lab & field test).
- i) **Recommendations:** (Based on the field and lab investigation the consultant shall give clear cut recommendation for):
 - Modulus of sub-grade Reaction, K-Value (Incase **PLT** is conducted) — supported with proper calculation etc.
 - RI. at which foundation of building structure can be placed.
 - Recommended foundation type.
 - If open foundation is recommended SBC of soil at 2 — 3 typical depths of foundation for square, rectangular & strip as well as raft foundation — supported with proper calculation.
 - Pile capacity for different dia./lengths, if pile foundation is recommended— supported with proper calculation.
 - SBC & depth of foundation for non-load bearing walls.
 - In case fissures are found in rock at foundation level, consultant shall give details of joining of two adjacent rocks to avoid splitting under imposed load.
 - Depth up to which the virgin soil need to be removed, if any.

- Ground improvement required, if any, along with detailed specifications, procedure for ground improvement including proper reasoning for value added.
- Local practice being followed, if any, for ground improvement.
- Local practice being followed, in case of filling areas. The consultant shall recommend the material for filling along with detailed specifications for compacting the same.

4. Terms & Conditions

- a. Since the entire construction project would be based on soil investigation report, the accuracy and adequacy of report shall be the criteria of the contract. Any sort of negligence makes the contractor/consultant liable to pay damages.
- b. The consultant will associate AAI engineers throughout the soil investigation work and shall provide AAI with all the details pertaining to the studies or works including collection of data.
- c. The work at site shall be carried out under full time supervision of a skilled geotechnical engineer, who shall be capable of coordinating and responsible for the entire work.
- d. Consultant shall make enquiries and verify regarding earlier use of the site, which can have important bearing on its suitability for the proposed structure.
- e. All tests shall be carried out as per latest provisions in concerned BIS code provisions including all applicable official amendments and revisions. The consultant may use any other code in case there is no BIS code for a particular test.
- f. The Consultant shall intimate AAI giving reasons, if any additional tests be considered necessary to be carried out duly considering the local soil conditions before starting of such tests.
- g. The Consultant shall interact with AAI in assessing load on columns and other structural elements, types of structures envisaged at the area under investigation so as to enable him to make specific recommendations for the depth, type of foundations and allowable bearing pressure.
- h. The Consultant shall be liable and responsible for the correctness and accuracy of the data, calculations, analysis and recommendations furnished by them. Should any inadequacy or discrepancy be observed in the work performed by the Consultant and recommendation made by them, the Consultant shall at his own initiatives perform all such survey/investigation and other works as may be necessary for adequacy of the recommendation/requirements without any extra cost.
- i. The report shall be submitted in triplicate.

Appendix 1B

Format for Submission of Soil Investigation Report for Building Works

SOIL INVESTIGATION REPORT

Name of Work :

Client: Airports Authority of India :

AAI Ref . Letter NO :

Period of Field
Investigation :

Date of Report :

CONTENTS

S. No.	Description	Page no.

Certified that this report contains pages 1to.....pages

Further all the tests have been conducted with high degree of reliability and accuracy.

Signature of Authorized

Signatory of Soil Consultant_____ dated _____

Name of Authorized Signatory _____

Designation of Authorized Signatory _____

Office Seal of Soil Consultant

Certified that the field investigation/collection of data for the above report has been carried out at

Signature _____ dated _____

Name of concerned Engineer of AAI _____

Designation _____

BORE LOG DATA SHEET

Project Name :

Bore Hole No.

Bore Hole started on.

Bore Hole completed on.

Depth of water Table

R. L. Ground Level:

Method of Drilling:

Diameter of Bore Hole:

Location of Bore Hole:

[illegible]

1. Lab Investigation: (Please provide Summary of various tests carried out in the lab).
6. Location Map: (Pl. give location map of the area under investigation clearly indicating Landmarks which can clearly identify the area under investigation. Further the location plan should also indicate test locations viz. boreholes, plate load tests, on a Well-Proportionate Scale).
5. Longitudinal Section: (Pl. Provide Longitudinal section of soil profile passing through various bore holes. The longitudinal section 'must indicate R L, water table, soil specification etc. at each borehole).
6. The Soil Profile: (PL Provide Detailed description of each layer /stratification of soil considering all the bore holes, lab & field test).

7. Recommendations: (Based on the field and lab investigation the consultant shall give clear cut recommendation for):
- a. Modulus of sub-grade Reaction, K-Value (Incase **PLT** is conducted) — supported with proper calculation etc.
 - b. RI. at which foundation of building structure can be placed
 - c. Recommended foundation type.
 - d. If open foundation is recommended SBC of soil at 2 — 3 typical depths of foundation for square, rectangular & strip as well as raft foundation — supported with proper calculation.
 - e. Pile capacity for different dia./lengths, if pile foundation is recommended— supported with proper calculation.
 - f. SBC & depth of foundation for non-load bearing walls.
 - g. In case fissures are found in rock at foundation level, consultant shall give details of joining of two adjacent rocks to avoid splitting under imposed load.
 - h. Depth up to which the virgin soil need to be removed, if any.
 - i. Ground improvement required, if any, along with detailed specifications, procedure for ground improvement including proper reasoning for value added..
 - j. Local practice being followed, if any, for ground improvement.
 - k. Local practice being followed, in case of filling areas. The consultant shall recommend the material for filling along with detailed specifications for compacting the same.

<div>NIT 1666</div> SUMMARY OF RECOMMENDATIONS								
Sl.	SBC T/SQ MTR	Depth below G.L.	Size of footing	Soil Classificat ion	Precautions, if any, IN THE Foundation Concrete w.r.t CLAUSE 8.2.2.4 & 9.1.2 (TABLE 4,5) IS 456-2000 i.e., 1. Type of Cement 2. Min. Cement Content	N-value and inference drawn in the light of cause 6.3.5.2 of IS 1893 (PT-I) 2002	For detail refer PAGE	Any other relevant information

No of sheets, for any topic, can be increased by Soil Consultant, depending upon length of matter.

Specifications for Carrying out Soil Investigation for Airfield Pavement Work

1. GENERAL

The soil consultant shall visit the site and shall carry out soil investigation as per the scope of work given below and shall submit the soil report as per the enclosed proforma.

2. OBJECTIVE

To decide safe & cost effective type of foundation, depth of foundation, load bearing capacity of soil, location of ground water and possible corrosive effects of soil and water on foundation material, ground improvement/soil treatment, if any, required before laying/casting of foundation.

In order to achieve the above objective, following engineering properties of the soil need to be evaluated:

- a) Soil type and its engineering properties
- b) Depth of water table
- c) Chemical properties of sub-soil and sub-soil water
- d) Sub soil profile indicating thicknesses of various soil strata upto the depth as indicated in

Table-1.

S.No	Area	Spacing	Depth	Minimum No of Bore Holes
1	Runways & Taxiways	Random across pavement at 70m intervals	Cut areas — 3.5m Below Finished Grade Fill areas — 3.5m Below Existing Ground*	3 Nos.
2	Other areas of Pavement	1 Boring per 930 sq m of Area	Cut areas — 3.5m Below Finished Grade Fill Areas — 3.5m Below Existing Ground*	3Nos.
3	Borrow Areas	Sufficient Tests to clearly define the borrow material	To depth of Borrow Excavation	3Nos.

* For deep fills, boring depths shall be sufficient to determine the extend of consolidation and/or slippage the fill may cause.

3. SCOPE OF WORK

- a. No., spacing and depth of bore holes as per Table-1.
- b. Collection of disturbed/undisturbed samples shall be done at 0.5m, 1.25m, 2.0m, 3.0m depth from existing ground level or change of strata whichever is earlier.
- c. Lab CBR tests —
 - i. CBR test shall be conducted at soil sample at proposed sub-grade level.
 - ii. Minimum 3Nos. CBR tests shall be conducted on each type of soil.
 - iii. Total No. of CBR tests shall not be less than 9Nos for the whole area.
- d. ## Modulus of sub-grade reaction — 3 No. Plate load tests (PLT) to be conducted at proposed sub-grade level for each pavement (i.e. for apron, Runway, taxiway etc.). PLT should be conducted as per 15:9214 with the following:
 - i. Circular Plate having 75cm diameter
 - ii. Minimum 3Nos dial gauges to be used for deflection measurement.
- e. Particle size analysis of soil- to be conducted on all samples.
- f. Triaxial Test- minimum 3 nos. tests.
- g. Liquid limit, Plastic Limit, Plasticity Index, Swell Index, Shrinkage limit — to be conducted on all samples for clayey and swelling soils.
- h. In situ density, dry density, Natural moisture content of soil - to be conducted on all samples.
- i. Permeability tests- to be conducted on granular soils minimum 3No.tests.
- j. Determination of organic material in soil by wet combustion- minimum 3No.tests.
- k. Determination of chlorides & sulphates in soil- minimum 3No.tests.
- l. Moisture — density relation of soil — to be conducted on all samples.
- m. Chemical analysis of ground water - minimum 3No.tests.
- n. Elastic modulus of soil at proposed sub-grade level- minimum 3No.tests.
- o. Poisson's ratio of soil at proposed sub-grade level- minimum 3No.tests.
- p. Recommendation of the consultant including soil stabilization/ground improvement. The consultant shall provide K/CBR Value at proposed sub-grade level.
- q. In case rock is encountered at a depth less than of equal to 1.5m below the proposed sub-grade level, tests for soil as stipulated in scope of work need not be carried out. In that situation, following tests on rocks shall be carried out:
 - i. Probing shall be done to ascertain rock profile.
 - ii. RQD and rock mass rating.
 - iii. Visual examination
 - iv. Unit weight
 - v. Water absorption
 - vi. Porosity

- vii. Petrographic analysis NIT-1669
- viii. Compressive strength
- ix. Shear strength
- x. Elastic modulus & Poisson's ratio

#- CBR Test to be conducted only for proposed Flexible Pavements

##- K- value Test to be conducted only for proposed Rigid Pavements.

4. Report shall include the following

- a. Introduction: (Please give description of work).
- b. Field Investigation: (Please give Summary of various tests carried out in the field).
- c. Field Investigation Photographs: (Please attach Photograph showing the field test in progress along with the concerned technician / Engineer)
- d. Lab Investigation: (Please give Summary of various tests carried out in the lab).
- e. Location Map: (Please give Location map of the area under investigation clearly indicating LONGITUDES (in case of runway/taxiway) or other land marks which can clearly identify the area under investigation. Further the location plan should also indicate test locations viz. boreholes, plate load tests, CBR Test. on a WELL-PROPORTIONATE SCALE),
- f. Longitudinal Section: (Please give longitudinal section of soil profile passing through various bore holes. The longitudinal section must indicate RL, water table, soil specification etc. at each borehole).
- g. The Soil Profile: (Pl. give Detailed description of each layer/stratification of soil considering all the bore holes, lab & field test).
- h. **Recommendations:** (Based on the field and lab investigation the consultant shall give clear cut recommendation for):
 - a) CBR Values supported with proper calculation etc. **In case CBR is less than 3, the soil consultant shall give suitable cost effective recommendations for ground improvement to raise the CBR to a minimum value of 3.**
 - ii) Modulus of sub-grade Reaction (K-Value) — supported with proper calculation etc. **In case the K-value is less than 3Kg/cm²/cm, the soil consultant shall give suitable cost effective recommendations for ground improvement to raise the K-value to a minimum value of 3Kg/cm²/cm.**
 - iii) R.L. at which pavement structure can be placed
 - iv) Depth up to which the virgin soil need to be removed, if any.
 - v) Ground improvement required, if any.

- NT-1670
- vi) Local practice being followed, if any, for ground improvement.
 - vii) Local practice being followed, in case of filling areas.
 - viii) Elastic modulus of soil at proposed sub-grade level.
 - ix) Poisson's Ratio of soil at proposed sub-grade level.
 - x) Surface drainage condition of area.

5. TERMS & CONDITIONS

- a) Since the entire construction project would be based on soil investigation report, the accuracy and adequacy of report shall be the criteria of the contract. Any sort of negligence makes the contractor/consultant liable to pay damages.
- b) The consultant will associate AAI engineers throughout the soil investigation work and shall provide MI with all the details pertaining to the studies or works including collection of data.
- c) The work at site shall be carried out under full time supervision of a skilled geotechnical engineer, who shall be capable of coordinating and responsible for the entire work.
- d) Consultant shall make enquiries and verify regarding earlier use of the site, which can have important bearing on its suitability for the proposed structure.
- e) All standards, specifications and codes of practice referred shall be latest edition including all applicable official amendments and revisions.

**Proforma for Submission of Soil Investigation Report for Airfield Pavement
works**

SOIL INVESTIGATION REPORT

NAME OF WORK:

CLIENT: AIRPORTS AUTHORITY OF INDIA

AAI REF. LETTER NO.

**PERIOD OF FIELD
INVESTIGATION:**

DATE OF REPORT:

CONTENTS

Sl.	Description	Page no.

Certified that this report contains pages 1 to and further all the test have
 Further all the tests have been conducted with high degree of reliability and accuracy.

Signature of Authorized

Signatory of Soil Consultant _____ dated _____

Name of Authorized Signatory _____

Designation of Authorized Signatory _____

Office Seal of Soil Consultant

Certified that the field investigation/collection of data for the above report has been
 carried out at the site.

Signature _____ dated _____

Name of concerned Engineer of AAI _____

Designation _____

BORE LOG DATA SHEET

Project Name :

Bore Hole No.

Bore Hole started on.

Bore Hole completed on.

Depth of water Table

R. L. Ground Level:

Method of Drilling:

Diameter of Bore Hole:

Location of Bore Hole:

[illegible]

5. Lab Investigation: (Pl. give Summary of various tests carried out in the lab).

6. Location Map: (Pl. give Location map of the area under investigation clearly indicating LONGITUDES (in case of runway/taxiway) or other land marks which can clearly identify the area under investigation. Further the location plan should also indicate test locations viz. Boreholes, plate load tests, CBR Test. On a WELL-PROPORTIONATE SCALE).

7. Longitudinal Section: (Pl. give ^{NE-1676} Longitudinal section of soil profile passing through various bore holes. The longitudinal section 'must indicate R L, water table, soil specification etc. at each borehole).

8. The Soil Profile: (PL give Detailed description of each layer /stratification of soil considering all the bore holes, lab & field test).

9. Recommendations: (Based on the field and lab investigation the consultant shall give clear cut recommendation for):
- i) CBR values supported with proper calculation etc. In case CBR is less than 3, the soil consultant shall give suitable cost effective recommendations for ground improvement to raise the CBR to a minimum value of 3.
 - ii) Modules of sub-grade Reaction (K-value) – supported with proper calculation etc. In case the K-value is less than $3\text{Kg/cm}^2/\text{cm}$, the soil consultant shall give suitable cost effective recommendations for ground improvement to raise the K-value to a minimum value of $3\text{Kg/cm}^2/\text{cm}$.
 - i) R.L. at which pavement structure can be placed.
 - ii) Depth up to which the virgin soil need to be removed, if any.
 - iii) Ground improvement required, if any.
 - iv) Local practice being followed, if any, for ground improvement.
 - v) Local practice being followed, in case of filling areas.
 - vi) Elastic modulus of soil at proposed sub-grade level.
 - vii) Poisson's Ratio of soil at proposed sub-grade level.
 - viii) Surface drainage condition of area.

No of sheets, for any topic, can be increased by soil Consultant, depending upon length of matter.

No of sheets, for any topic, can be increased by Soil Consultant, depending upon length of matter.

SUMMARY OF RECOMMENDATIONS								
S.no .	SBC t/sqmt r	Depth below ground level	Size of footing	Soil classifica tion	Precautions, if any, in the foundation concrete w.r.t clause 8.2.2.4 & 9.1.2 (table 4,5) is 456-2000 i.e., 1. Type of cement 2. Min. Cement content	N-value and inference drawn in the light of cause 6.3.5.2 of is 1893 (pt-i) 2002	For detail refer page	Any other relevant information

M T L

MTL

Marshal Test Labs (I) Pvt. Ltd.

A NABL Accredited Lab

Laboratory for testing of Civil Engineering (Roads & Buildings) Materials

SOIL INVESTIGATION WORK FOR DEVELOPMENT OF UJJAIN - AIRPORT

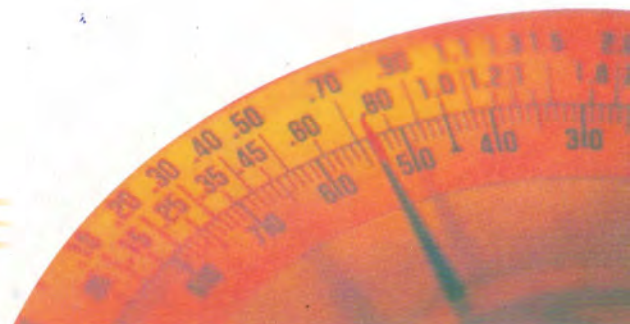
<< << Prepared for >> >>

THE DEPUTY GENERAL MANAGER (ENGG.-CIVIL)
AIRPORT AUTHORITY OF INDIA
D.A.B.H., AIRPORT, INDORE (M.P.)



M/S. MARSHAL TEST LABS (I) PVT LTD.,
6 & 7 FOURTH FLOOR, DAWA BAZAR,
13-14 RNT MARG, INDORE - 452001 (MADHYA PRADESH)
E-Mail : marshal@mtlipl.com

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13-14 R.N.T. Marg, Indore - 452 001 (M.P.)
Tel.: 0731-4244246, 4244226,
email : marshal@mtlipl.com Web. : www.mtlipl.com



M T L

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Laboratory for testing of Civil Engineering (Roads & Buildings) Materials

Page 2

SOIL EXPLORATION REPORT**CONTRACTOR**: THE DEPUTY GENERAL MANAGER (ENGG.-CIVIL)
AIRPORT AUTHORITY OF INDIA
D.A.B.H., AIRPORT, INDORE (M.P.)**PROJECT**: SOIL INVESTIGATION WORK FOR DEVELOPMENT OF UJJAIN -
AIRPORT**TOTAL NUMBER OF BORE
HOLES**

: 11 Nos



M/S. MARSHAL TEST LABS (I) PVT LTD.,
6 & 7 FOURTH FLOOR, DAWA BAZAR,
13-14 RNT MARG, INDORE - 452001 (MADHYA PRADESH)
E-Mail : marshal@mtlipl.com

Regd. Off. : 6 & 7, Fourth Floor, Dawa Bazar,
13-14 R.N.T. Marg, Indore - 452 001 (M.P.)
Tel.: 0731-4244246, 4244226,
email : marshal@mtlipl.com Web. : www.mtlipl.com



M T L

MTL

Marshal Test Labs (I) Pvt. Ltd.

A NABL Accredited Lab

Laboratory for testing of Civil Engineering (Roads & Buildings) Materials

MTL/Desp/21112510

Date: - 05/12/2025

To,
THE DEPUTY GENERAL MANAGER (ENGG.-CIVIL)
AIRPORT AUTHORITY OF INDIA
D.A.B.H., AIRPORT, INDORE (M.P.)

Subject: - SOIL INVESTIGATION WORK FOR DEVELOPMENT OF UJJAIN - AIRPORT

Your Ref.: - Lab TRQ Dt. 21/11/2025

Dear Sir,

We are pleased to submit herewith the Soil Report for the above proposed site. This is for favour of your kind reference and record please.

Thanking you.

Yours faithfully



For Marshal Test Labs (I) Pvt. Ltd.
AUTHORIZED SIGNATORY

M/S. MARSHAL TEST LABS (I) PVT LTD.,
6 & 7 FOURTH FLOOR, DAWA BAZAR,
13-14 RNT MARG, INDORE - 452001 (MADHYA PRADESH)
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Tel.: 0731-4244246, 4244226,
email : marshal@mtlipl.com Web. : www.mtlipl.com



NO.	CONTENTS
1	Introduction
2	Objectives
3	Laboratory Tests

1 Introduction:-

Testing of Samples of Boreholes samples is carried out for THE DEPTUY GENERAL MANAGER (ENGG.-CIVIL) AIRPORT AUTHORITY OF INDIA D.A.B.H., AIRPORT, INDORE (M.P.) for SOIL INVESTIGATION WORK FOR DEVELOPMENT OF UJJAIN - AIRPORT. Testing was intended to assess the nature of subsoil strata for evaluating sub soil parameters and Safe bearing Capacity of Soil stratum and other physical parameters necessary for design of suitable Foundation. This report presents the findings of the Laboratory testing carried out by us.

2 Objective:-

The Objective of Testing is to provide the Designer

To ascertain the Sub - Soil Strata at Site

To Study standing Ground Water Level

To Study the Physical and Engineering Properties of Soil Strata

To Evaluate allowable safe bearing capacity of soils



2 Filed Investigation :-

2.1 Standard Penetration Test :- IS : 2131

Standard Penetration test was conducted in accordance to IS 2131 using a standard split spoon sampler (51mm OD and 38mm ID and Length of 650 mm) Driven by 63.50 Kg Drop weight tripping automatically with a free fall of 750 mm

The Number of Hammer blows required to drive 150 mm of the sample is counted. The sampler is further driven by 150 mm and the number of blows recorded.

Like Wise the sampler is once again further driven by 150 mm and the number of blows recorded. The number of blows recorded for the first 150 mm is disregarded. The number of blows recorded for the last two 150 mm intervals are added to give the standard

3. FIELD INVESTIGATIONS

3.1 Rotary Boring :

Rotary Boring was Performed at Nine Locations in accordance with IS : 1892

In this method, boring is effected by the cutting action of a rotating bit which is kept in firm contact with the bottom of the hole. The bit is attached to the lower end of a hollow drill rod which is rotated by a suitable chuck. Drilling mud (Usually Bentonite) is continuously forced down the hollow drill rods. The Mud returning upwards through the annular space between the drill rods and the side of the hole brings the cuttings to the surface.

Boring Was carried out in weathered rock stratum using TC bit attached to the lower end of the hollow drill rod. While boring in soft rock/hard rock stratum. NX Size Diamond Bit was used.



4 Laboratory Test

Appropriate Laboratory Tests were Conducted on the Soil Samples obtained from Bore





- 4.1 Moisture Content (IS : 2720 (Part - 8) - 1983)
- 4.2 Grain Size Analysis (IS : 2720 (Part - 4) - 1985)
- 4.3 Atterberg's Limit (LL, PL & PI) (IS : 2720 (Part - 5) - 1985)
- 4.4 C Value of Soil (IS-2720-PART-13-1986)
- 4.5 Φ value of Soil (IS-2720-PART-13-1986)



INDEX

SR. NO.	NAME TEST	PAGE NO.
	<u>Bore Hole - 1 Strata Details & Test Results</u>	
1	Bore Log Strata Details & Test Results	8 to 13
	<u>Bore Hole - 2, Strata Details & Test Results</u>	
2	Bore Log Strata Details & Test Results	14 to 19
	<u>Bore Hole - 3, Strata Details & Test Results</u>	
3	Bore Log Strata Details & Test Results	20 to 25
	<u>Bore Hole - 4, Strata Details & Test Results</u>	
4	Bore Log Strata Details & Test Results	26 to 35
	<u>Bore Hole - 5, Strata Details & Test Results</u>	
5	Bore Log Strata Details & Test Results	36 to 42
	<u>Bore Hole - 6, Strata Details & Test Results</u>	
6	Bore Log Strata Details & Test Results	43 to 49
	<u>Bore Hole - 7, Strata Details & Test Results</u>	
7	Bore Log Strata Details & Test Results	50 to 59
	<u>Bore Hole - 8, Strata Details & Test Results</u>	
8	Bore Log Strata Details & Test Results	60 to 69
	<u>Bore Hole - 9, Strata Details & Test Results</u>	
9	Bore Log Strata Details & Test Results	70 to 76
	<u>Bore Hole - 10, Strata Details & Test Results</u>	
10	Bore Log Strata Details & Test Results	77 to 83
	<u>Bore Hole - 11, Strata Details & Test Results</u>	
11	Bore Log Strata Details & Test Results	84 to 90
	<u>EXCAVATE PIT</u>	
10	OMC, MDD & CBR Value	91 to 92
11	GENERAL RECOMMENDATION	93



MARSHAL TEST LABS (I) PVT. LTD.,																	
BORE LOG DETAILS OF SOIL INVESTIGATION																	
CONTRACTOR		The DGM AAI, DABH, Airport, Indore.															
PROJECT		Soil Investigation Work for Development of UJJAIN - AIRPORT															
LOCATION		L4															
BORE LOG NO.		01															
Depth Below G.L. (Mtr.)	Profile	Description of Strata	Thickness of Layer (Mtr.)	Standard Penetration Test		Depth at Which test is conducted (Mtr.)	Laboratory Test Results										
				Depth in Mtr.	N Value		Grain Size Analysis			Atterberg's Limit			Shear Test		ALLOWABLE SAFE BEARING CAPACITY T/M2	POINT LOAD STRENGTH INDEX TEST FOR SBC T/M ²	
0.00 to 0.70		BITUMINOUS + MOORUM	0.70	---	---	---	Bulk Density (gm/cc)	Moisture Content (%)	Gravel (%)	Sand (%)	Silt + Clay (%)	LL (%)	PL (%)	PI (%)			Free Swell Index (%)
0.70 to 2.50		BLACK COTTON	1.80	1.5	11	---	1.801	17.79	0.00	2.62	97.38	59	35	24	58.1	---	---
2.50 to 3.00		YELLOW SOIL	0.50	---	---	2.80	1.953	13.38	4.12	42.50	53.38	46	29	17	41.79	0.45	11.10
3.00 to 6.00		BOULDER	3.50	3.0	>50	3.50	---	---	---	---	---	---	---	---	---	---	---
				4.5	---	4.50	---	---	---	---	---	---	---	---	---	---	---
				6.0	---	---	---	---	---	---	---	---	---	---	---	---	---
Borehole Terminated @ 6.00 M																	



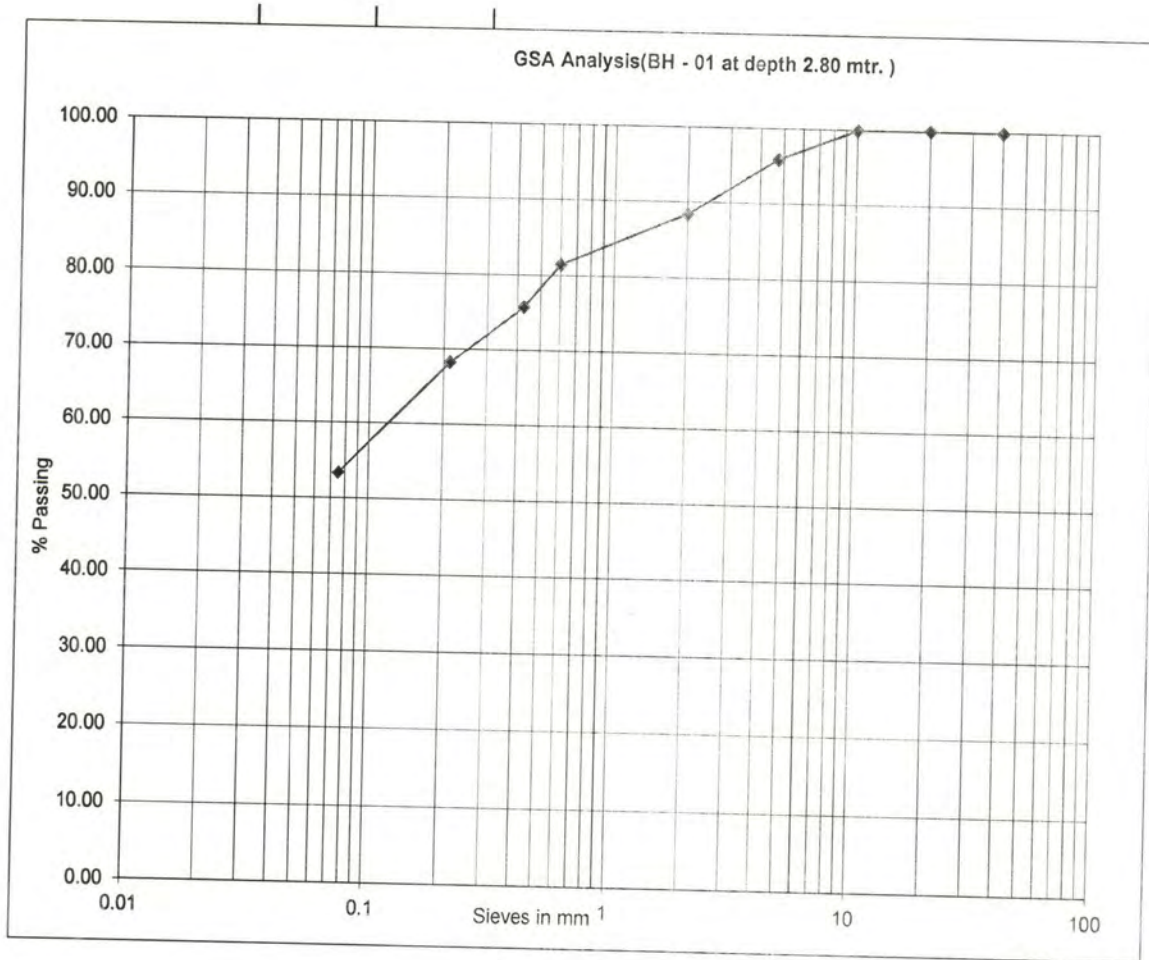
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BH - 01Nature : - YELLOW SOIL

S. No.	Name of Test	Test Method	Results	Unit
1	Moisture Content	As Per IS : Specification	13.38	%
2	Atterberg's Limit of Soil			
a)	LL		46	%
b)	PL		29	
c)	PI		17	
3	Grain Size Analyses			
a)	Gravel		4.12	%
b)	Sand		42.50	%
c)	Silt + Clay		53.38	%
4	C Value (Kg/Cm ²)		0.45	Kg/cm ²
5	Φ value of Soil (°)		11.10	°
6	Allowable Bearing Capacity			
a)	Depth 2.80 Mtr.		14.25	T/M ²

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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 2.800m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 19.53kN/m³.Bulk density (W) of soil below Foundation base : 19.53kN/m³.Cohesion C' : 30.00kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.213	Ic = 1.000
Sq = 1.200	Dq = 1.000	Iq = 1.000
Sg = 0.800	Dg = 1.000	Ig = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 54.68kN/m².******For local shear Failure******

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot Ic + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot Iq + 0.5 \cdot B \cdot W' \cdot N'_g \cdot Sg \cdot Dg \cdot Ig \cdot W'$
 Effective angle of internal friction(ϕ') : 7.45

Bearing capacity factors

N'_c = 7.32N'_q = 1.96N'_g = 0.77Thus $Q_{ult_n} = 427.40 \text{ kN/m}^2$.Allowable Safe bearing capacity (Q_{ns}) = 14.25 T/m².

BH - 1

Nature : - Rock Lump SampleDepth - 3.50 Mtr.

Sample No.	Point Load Lump Strength Index Test I_L (50)	Uniaxial Compressive Strength (q_c)	Unit
1	1.24	18.64	Kgf/Cm ²
2	1.85	27.76	Kgf/Cm ²
3	1.04	15.54	Kgf/Cm ²
4	1.44	21.67	Kgf/Cm ²
5	0.88	13.24	Kgf/Cm ²
6	1.48	22.24	Kgf/Cm ²
7	1.11	16.64	Kgf/Cm ²
8	1.37	20.55	Kgf/Cm ²
9	1.31	19.64	Kgf/Cm ²
10	1.71	25.64	Kgf/Cm ²
Mean	1.33	19.90	Kgf/Cm ²

The Mean Value of Uniaxial Compressive Strength of Above Samples (Calculate as per clause 7.1.2 IS - 8764 : 1998) Calculates to **19.90 Kgf/Cm²**. For Safe Bearing Capacity, the Factor of Safety can be taken as 08 (Based on General Engineering Practice); Thus S.B.C. can be Taken as **24.87 T/M²**.



BH - 1

Nature : - Rock Lump Sample

Depth - 4.50 Mtr.

Sample No.	Point Load Lump Strength Index Test I_L (50)	Uniaxial Compressive Strength (q_c)	Unit
1	1.45	21.78	Kgf/Cm ²
2	2.35	35.30	Kgf/Cm ²
3	1.52	22.87	Kgf/Cm ²
4	2.15	32.19	Kgf/Cm ²
5	1.26	18.86	Kgf/Cm ²
6	1.29	19.35	Kgf/Cm ²
7	1.66	24.86	Kgf/Cm ²
8	1.40	20.94	Kgf/Cm ²
9	1.54	23.11	Kgf/Cm ²
10	1.72	25.76	Kgf/Cm ²
Mean	1.55	23.22	Kgf/Cm ²

The Mean Value of Uniaxial Compressive Strength of Above Samples (Calculate as per clause 7.1.2 IS - 8764 : 1998) Calculates to **23.22 Kgf/Cm²**. For Safe Bearing Capacity, the Factor of Safety can be taken as 08 (Based on General Engineering Practice); Thus S.B.C. can be Taken as **29.03 T/M²**.



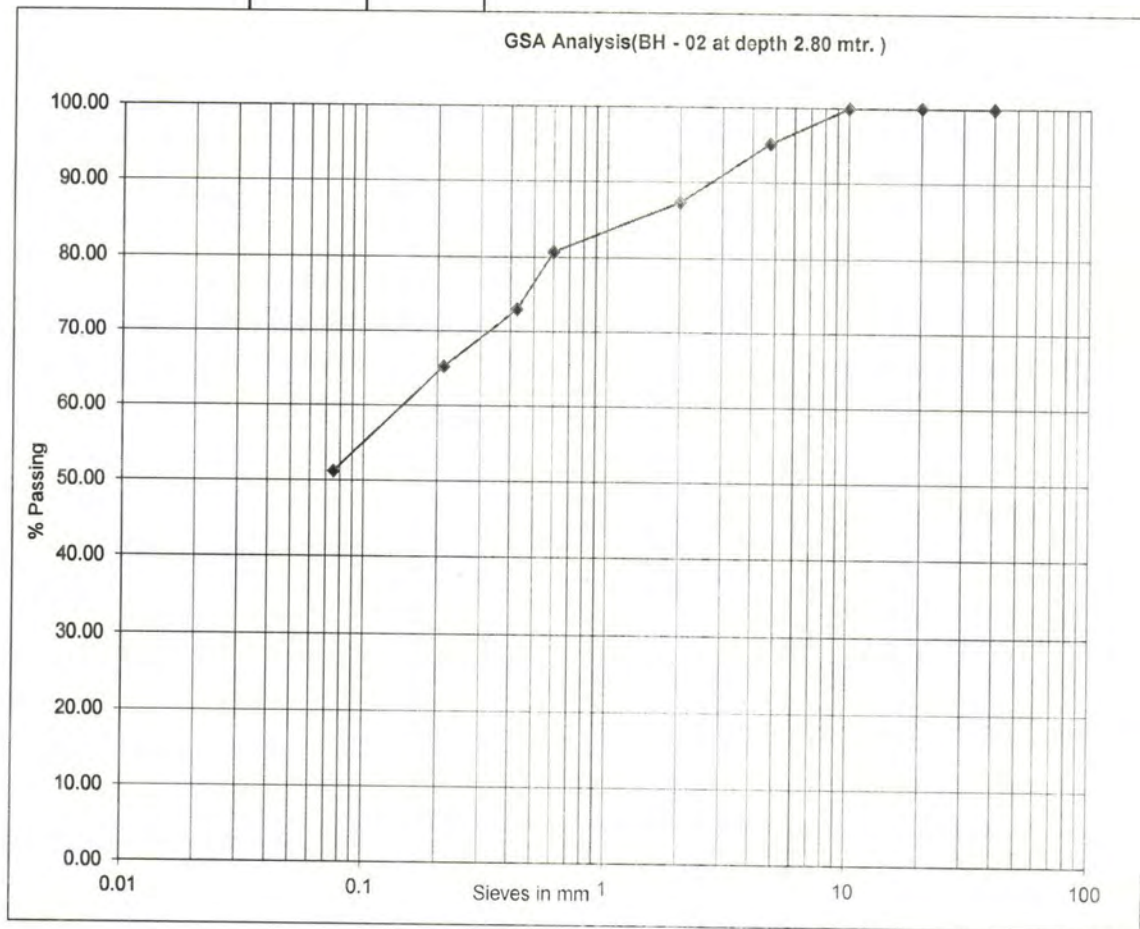
SUBMITTED BY MARSHAL TEST LABS (I) PVT. LTD.
 Off- 687 4th Floor
 Dawa Bazar
 R.M. Road
 Indore M.P.
 MARSHAL TEST LABS (I) PVT. LTD.
 INDORE

BH - 02Nature : - YELLOW SOIL

S. No.	Name of Test	Test Method	Results	Unit
1	Moisture Content	As Per IS : Specification	13.01	%
2	Atterberg's Limit of Soil			
a)	LL		43	%
b)	PL		29	
c)	PI		14	
3	Grain Size Analyses			
a)	Gravel		4.86	%
b)	Sand		43.95	%
c)	Silt + Clay		51.19	%
4	C Value (Kg/Cm ²)		0.44	Kg/cm ²
5	Φ value of Soil (°)		12.20	°
6	Allowable Bearing Capacity			
a)	Depth 2.80 Mtr.		14.86	T/M ²

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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 2.800m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 19.58kN/m³.Bulk density (W) of soil below Foundation base : 19.58kN/m³.Cohesion C' : 29.33kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.216	lc = 1.000
Sq = 1.200	Dq = 1.000	lq = 1.000
Sg = 0.800	Dg = 1.000	lg = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 54.82kN/m².******For local shear Failure******

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot lc + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot lq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot lg \cdot W'$
 Effective angle of internal friction(ϕ') : 8.20

Bearing capacity factors

N'_c = 7.61N'_q = 2.10N'_g = 0.89Thus $Q_{ult_n} = 445.74 \text{ kN/m}^2$.Allowable Safe bearing capacity (Qns) = 14.86 T/m².

BH - 2Nature : - Rock Lump SampleDepth - 3.50 Mtr.

Sample No.	Point Load Lump Strength Index Test I_L (50)	Uniaxial Compressive Strength (q_c)	Unit
1	1.54	23.15	Kgf/Cm ²
2	1.85	27.76	Kgf/Cm ²
3	1.42	21.35	Kgf/Cm ²
4	1.66	24.86	Kgf/Cm ²
5	1.35	20.19	Kgf/Cm ²
6	1.69	25.34	Kgf/Cm ²
7	1.94	29.06	Kgf/Cm ²
8	1.80	27.06	Kgf/Cm ²
9	2.14	32.11	Kgf/Cm ²
10	2.23	33.44	Kgf/Cm ²
Mean	1.75	26.21	Kgf/Cm ²

The Mean Value of Uniaxial Compressive Strength of Above Samples (Calculate as per clause 7.1.2 IS - 8764 : 1998) Calculates to **26.21 Kgf/Cm²**. For Safe Bearing Capacity, the Factor of Safety can be taken as 08 (Based on General Engineering Practice); Thus S.B.C. can be Taken as **32.76 T/M²**.



BH - 2

Nature : - Rock Lump Sample

Depth - 4.50 Mtr.

Sample No.	Point Load Lump Strength Index Test I_L (50)	Uniaxial Compressive Strength (q_c)	Unit
1	2.69	40.38	Kgf/Cm ²
2	1.90	28.57	Kgf/Cm ²
3	2.06	30.86	Kgf/Cm ²
4	1.76	26.35	Kgf/Cm ²
5	1.73	25.91	Kgf/Cm ²
6	1.34	20.16	Kgf/Cm ²
7	1.99	29.78	Kgf/Cm ²
8	2.38	35.65	Kgf/Cm ²
9	2.50	37.50	Kgf/Cm ²
10	1.48	22.16	Kgf/Cm ²
Mean	1.97	29.52	Kgf/Cm ²

The Mean Value of Uniaxial Compressive Strength of Above Samples (Calculate as per clause 7.1.2 IS - 8764 : 1998) Calculates to **29.52 Kgf/Cm²**. For Safe Bearing Capacity, the Factor of Safety can be taken as 08 (Based on General Engineering Practice); Thus S.B.C. can be Taken as **36.90 T/M²**.



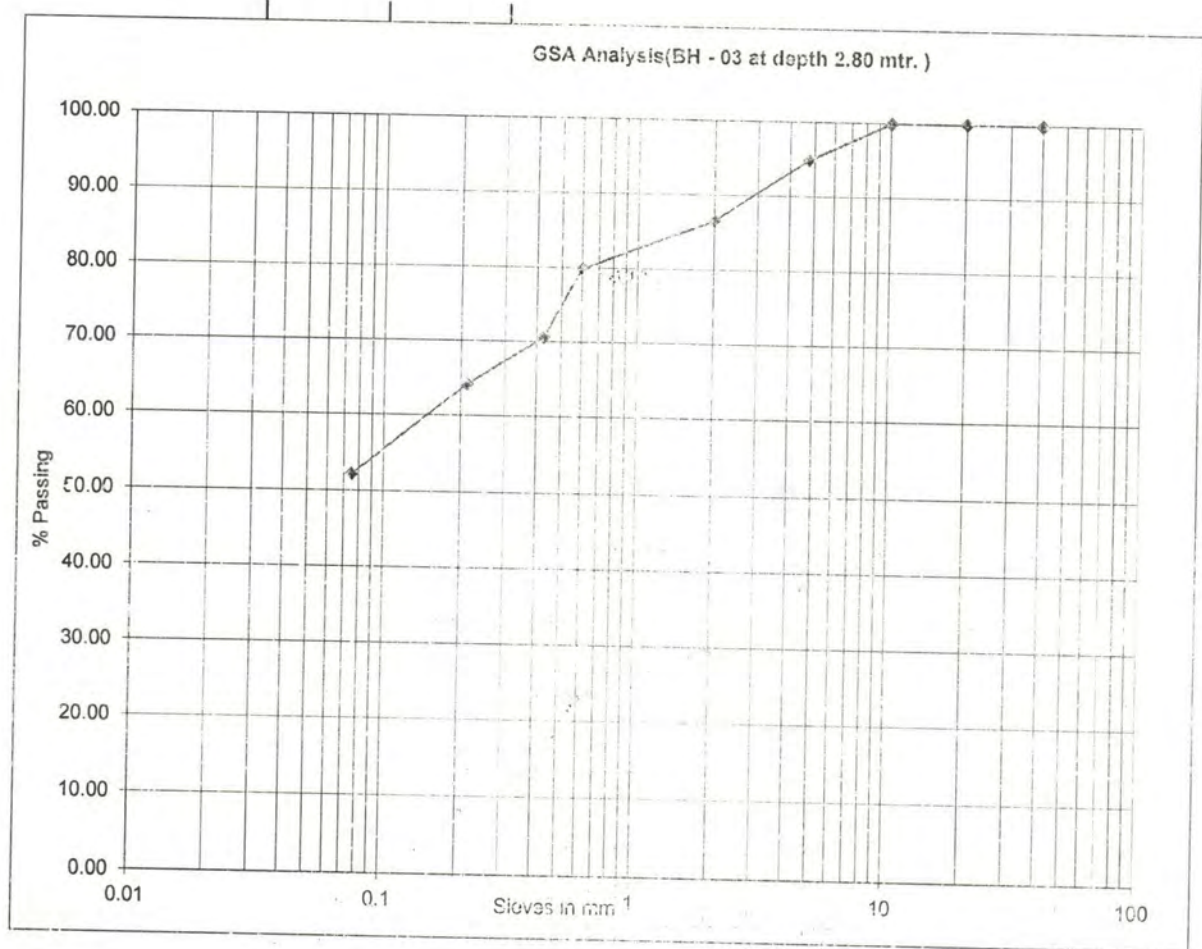
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BH - 03Nature : - YELLOW SOIL

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	1.961	gm/cc
2	Moisture Content		12.99	%
3	Atterberg's Limit of Soil			
a)	LL		43	%
b)	PL		29	
c)	PI		14	
4	Grain Size Analyses			
a)	Gravel		5.06	%
b)	Sand		42.76	%
c)	Silt + Clay		52.18	%
5	C Value (Kg/Cm ²)		0.43	Kg/cm ²
6	Φ value of Soil (°)		12.80	°
7	Allowable Bearing Capacity			
a)	Depth 2.80 Mtr.		15.09	T/M ²



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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 2.800m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 19.61kN/m³.

Bulk density (W) of soil below Foundation base : 19.61kN/m³.

Cohesion C' : 28.87kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.217	Ic = 1.000
Sq = 1.200	Dq = 1.000	Iq = 1.000
Sg = 0.800	Dg = 1.000	Ig = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 54.91kN/m².

****For local shear Failure****

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot Ic + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot Iq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot Ig \cdot W'$
Effective angle of internal friction(ϕ') : 8.61

Bearing capacity factors

N'_c = 7.77

N'_q = 2.18

N'_g = 0.96

Thus $Q_{ult_n} = 452.54 \text{ kN/m}^2$.

Allowable Safe bearing capacity (Q_{ns}) = 15.09 T/m².



BH - 3

Nature : - Rock Lump SampleDepth - 3.50 Mtr.

Sample No.	Point Load Lump Strength Index Test I_L (50)	Uniaxial Compressive Strength (q_c)	Unit
1	1.01	15.19	Kgf/Cm ²
2	2.04	30.55	Kgf/Cm ²
3	1.36	20.35	Kgf/Cm ²
4	1.26	18.86	Kgf/Cm ²
5	1.17	17.48	Kgf/Cm ²
6	2.16	32.36	Kgf/Cm ²
7	1.12	16.86	Kgf/Cm ²
8	1.31	19.58	Kgf/Cm ²
9	1.43	21.48	Kgf/Cm ²
10	1.38	20.65	Kgf/Cm ²
Mean	1.32	19.73	Kgf/Cm ²

The Mean Value of Uniaxial Compressive Strength of Above Samples (Calculate as per clause 7.1.2 IS - 8764 : 1998) Calculates to **19.73 Kgf/Cm²**. For Safe Bearing Capacity, the Factor of Safety can be taken as 08 (Based on General Engineering Practice); Thus S.B.C. can be Taken as **24.67 T/M²**.

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BH - 3

Nature : - Rock Lump Sample**Depth - 5.00 Mtr.**

Sample No.	Point Load Lump Strength Index Test i_L (50)	Uniaxial Compressive Strength (q_c)	Unit
1	1.70	25.48	Kgf/Cm ²
2	2.70	40.49	Kgf/Cm ²
3	3.82	57.35	Kgf/Cm ²
4	2.78	41.07	Kgf/Cm ²
5	3.33	49.94	Kgf/Cm ²
6	2.00	29.94	Kgf/Cm ²
7	2.82	42.24	Kgf/Cm ²
8	1.84	27.61	Kgf/Cm ²
9	3.93	58.35	Kgf/Cm ²
10	3.01	45.09	Kgf/Cm ²
Mean	2.58	38.67	Kgf/Cm ²

The Mean Value of Uniaxial Compressive Strength of Above Samples (Calculate as per clause 7.1.2 IS - 8764 : 1998) Calculates to **38.67 Kgf/Cm²**. For Safe Bearing Capacity, the Factor of Safety can be taken as 08 (Based on General Engineering Practice); Thus S.B.C. can be Taken as **48.34 T/M²**.

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MARSHAL TEST LABS (I) PVT. LTD., BORE LOG DETAILS OF SOIL INVESTIGATION												
CONTRACTOR		The DGM AAI, DABH, Airport, Indore.										
PROJECT		Soil Investigation Work for Development of UJJAIN - AIRPORT										
LOCATION		L5										
BORE LOG NO.		04										
Depth Below G.L. (Mtr.)	Profile	Description of Strata	Thickness of Layer (Mtr.)	Standard Penetration Test		Depth at Which test is conducted (Mtr.)		Laboratory Test Results			Shear Test	ALLOWABLE SAFE BEARING CAPACITY T/M2
				Depth in Mtr.	N Value							
0.00 to 2.00		BLACK COTTON	2.00	1.5	13	---	1.804	Bulk Density (gm/cc)				
2.00 to 4.50		YELLOW SOIL	2.50	3.0	29	4.0 3.0	1.972 1.964	Moisture Content (%)				
4.50 to 6.00		BLACK SANDY MATERIAL	1.50	4.5	>50	5.00	2.031	Grain Size Analysis				
				6.0	---		10.24	Gravel (%)				
							0.00	Sand (%)				
							87.75	Silt + Clay (%)				
							12.25	LL (%)				
								PL (%)				
								PI (%)				
								Free Swell Index (%)				
							17.50	C Value (Kg/Cm ²)				
							0.10	Φ value of Soil (°)				
							22.40					
							22.67					

Borehole Terminated @ 6.00 M

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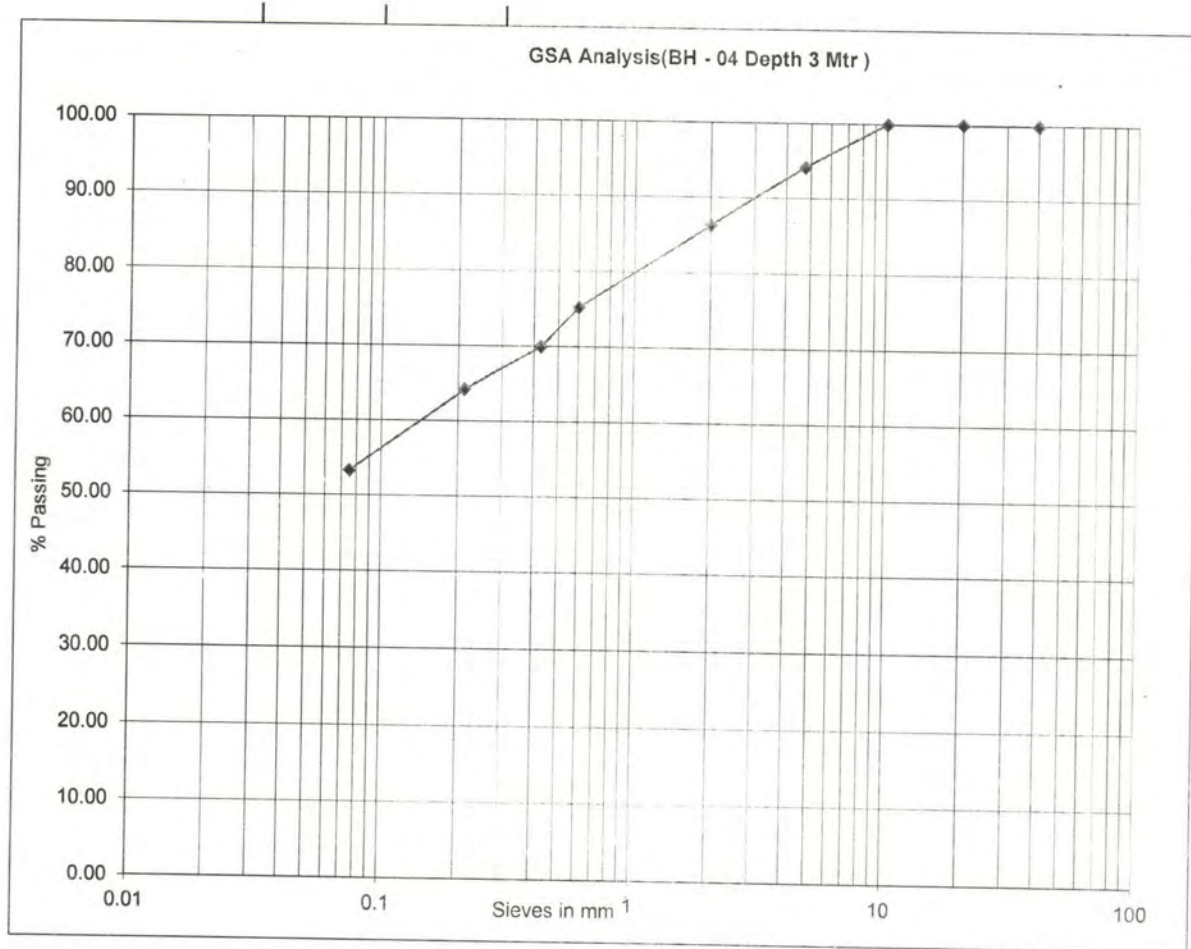


BH - 04Nature : - YELLOW SOIL

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	1.964	gm/cc
2	Moisture Content		13.21	%
3	Atterberg's Limit of Soil			
a)	LL		45	%
b)	PL		29	
c)	PI		16	
7	Grain Size Analyses			
a)	Gravel		5.86	%
b)	Sand		40.90	%
c)	Silt + Clay		53.24	%
8	C Value (Kg/Cm ²)		0.43	Kg/cm ²
9	Φ value of Soil (°)		13.10	°
10	Allowable Bearing Capacity			
a)	Depth 3.00 Mtr.		15.69	T/M ²

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****Sample calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 3.000m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 19.64kN/m³.

Bulk density (W) of soil below Foundation base : 19.64kN/m³.

Cohesion C' : 28.67kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.233	Ic = 1.000
Sq = 1.200	Dq = 1.000	Iq = 1.000
Sg = 0.800	Dg = 1.000	Ig = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 58.92kN/m².

*****For local shear Failure*****

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot Ic + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot Iq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot Ig \cdot W'$
 Effective angle of internal friction(ϕ') : 8.82

Bearing capacity factors

N'_c = 7.85

N'_q = 2.22

N'_g = 1.00

Thus $Q_{ult_n} = 470.54 \text{ kN/m}^2$.

Allowable Safe bearing capacity (Q_{ns}) = 15.69 T/m².

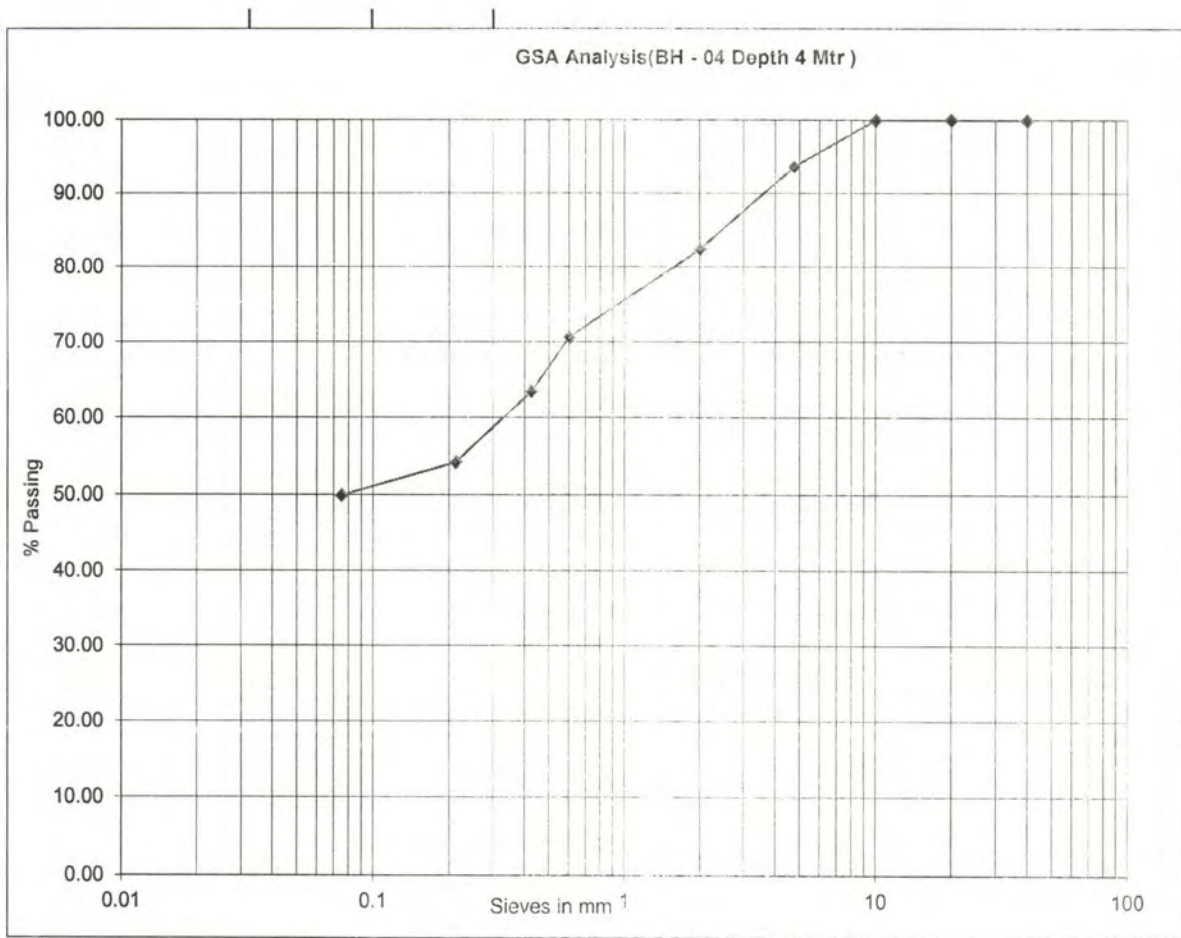


BH - 04Nature : - YELLOW SOIL

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	1.972	gm/cc
2	Moisture Content		12.86	%
3	Atterberg's Limit of Soil			
a)	LL		43	%
b)	PL		30	
c)	PI		13	
7	Grain Size Analyses			
a)	Gravel		6.37	%
b)	Sand		43.71	%
c)	Silt + Clay		49.92	%
8	C Value (Kg/Cm ²)		0.42	Kg/cm ²
9	Φ value of Soil (°)		13.80	°
10	Allowable Bearing Capacity			
a)	Depth 4.00 Mtr.		17.85	T/M ²

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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 4.000m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 19.72kN/m³.

Bulk density (W) of soil below Foundation base : 19.72kN/m³.

Cohesion C' : 28.00kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.314	Ic = 1.000
Sq = 1.200	Dq = 1.000	Iq = 1.000
Sg = 0.800	Dg = 1.000	Ig = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 78.88kN/m².

****For local shear Failure****

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot Ic + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot Iq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot Ig \cdot W'$

Effective angle of internal friction(ϕ') : 9.30

Bearing capacity factors

N'_c = 8.05

N'_q = 2.32

N'_g = 1.09

Thus $Q_{ult_n} = 535.40 \text{ kN/m}^2$.

Allowable Safe bearing capacity (Q_{ns}) = 17.85 T/m².



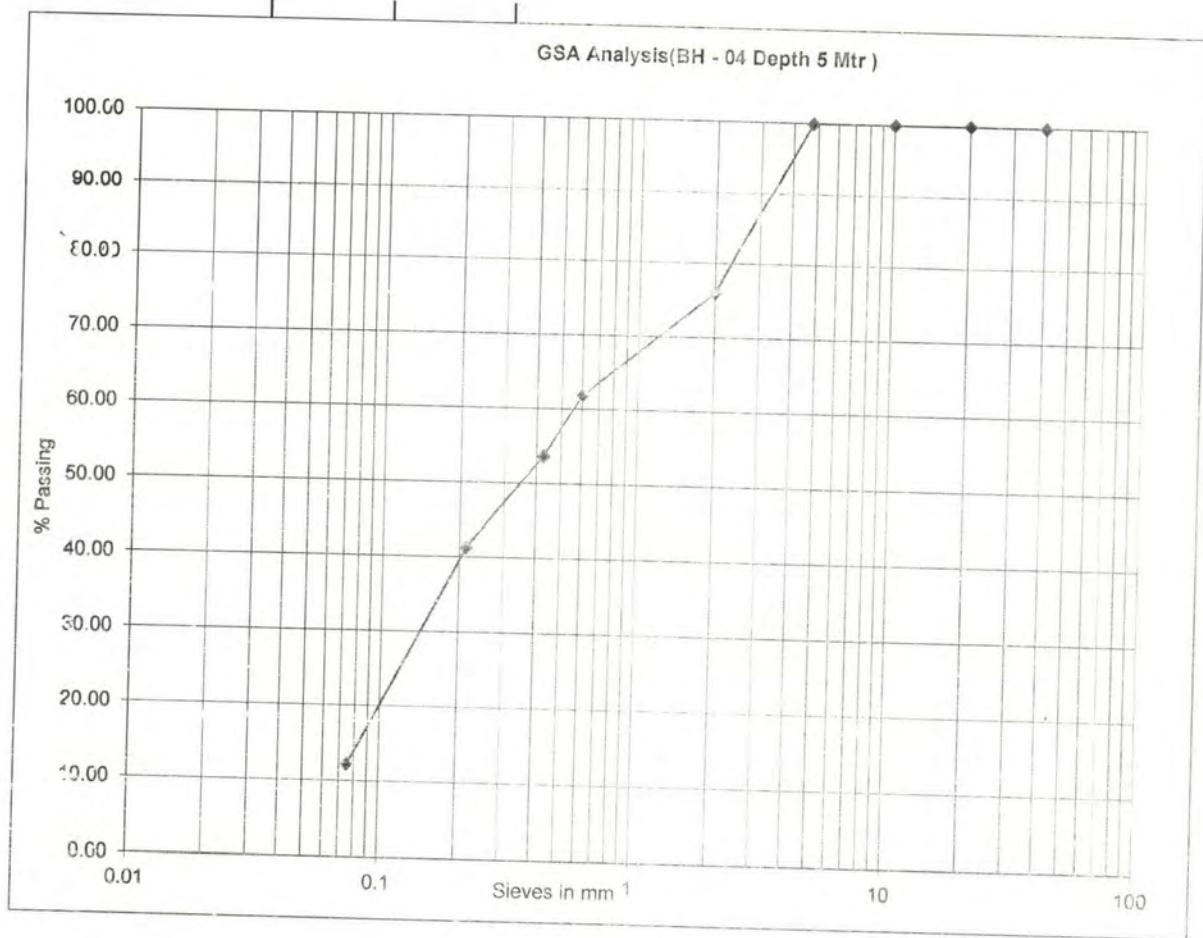
BH - 04

Nature : - BLACK SANDY MATERIAL

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	2.031	gm/cc
2	Moisture Content		10.24	%
3	Atterberg's Limit of Soil			
a)	LL		NON PLASTIC	%
b)	PL			
c)	PI			
7	Grain Size Analyses			
a)	Gravel		0.00	%
b)	Sand		87.75	%
c)	Silt + Clay		12.25	%
8	C Value (Kg/Cm ²)		0.10	Kg/cm ²
9	Φ value of Soil (°)		22.40	°
10	Allowable Bearing Capacity			
a)	Depth 5.00 Mtr.		22.67	T/M ²

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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 5.000m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 20.31kN/m³

Bulk density (W) of soil below Foundation base : 20.31kN/m³

Cohesion C' : 6.67kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.437	Ic = 1.000
Sq = 1.200	Dq = 1.219	Iq = 1.000
Sg = 0.800	Dg = 1.219	Ig = 1.000

Effective surcharge at base level q = 101.55kN/m².

****For local shear Failure****

Ultimate Net B.C = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot Ic + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot Iq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot Ig \cdot W'$
Effective angle of internal friction(phi') : 15.36

Bearing capacity factors

N'_c = 11.21

N'_q = 4.08

N'_g = 2.79

Thus $Q_{ult_n} = 680.25 \text{ kN/m}^2$.

Allowable Safe bearing capacity (Q_{ns}) = 22.67 N/m^2 .



MARSHAL TEST LABS (I) PVT. LTD., BORE LOG DETAILS OF SOIL INVESTIGATION													
CONTRACTOR: The DGM AA, DASH, Airport, Indore.													
PROJECT: Soil Investigation Work for Development of UJJAIN - AIRPORT													
LOCATION: L7													
BORE LOG NO.: 65													
Depth Below G.L. (Mtr.)	Profile	Description of Strata	Thickness of Layer (Mtr.)	Standard Penetration Test		Depth at Which test is conducted (Mtr.)	Laboratory Test Results						
				Depth in Mtr.	N Value		Grain Size Analysis			Atterberg's Limit			Shear Test
0.00 to 2.00		BLACK COTTON	2.00	1.5	10.0	---	Bulk Density (gm/cc)	1.788		Moisture Content (%)	18.34		
				3.00	26	3.00		1.948			13.86		
				4.50	34	4.50		1.959			13.33		
2.00 to 6.00		YELLOW SOIL	4.00	6.00	46	---	Gravel (%)	5.18	4.39	0.00			
							Sand (%)	42.53	37.83	1.06			
							Silt + Clay (%)	52.24	57.78	98.94			
							LL (%)	43	46	59			
							PL (%)	29	28	34			
							PI (%)	14	18	25			
							Free Swell Index (%)	41.18	44.12	62.30			
							C Value (Kg/Cm ²)	0.43	0.45	---			
							Φ value of Soil (°)	13.70	12.00	---			
							ALLOWABLE SAFE BEARING CAPACITY T/M2	18.91	15.26	---			

Borehole Terminated @ 6.00 M



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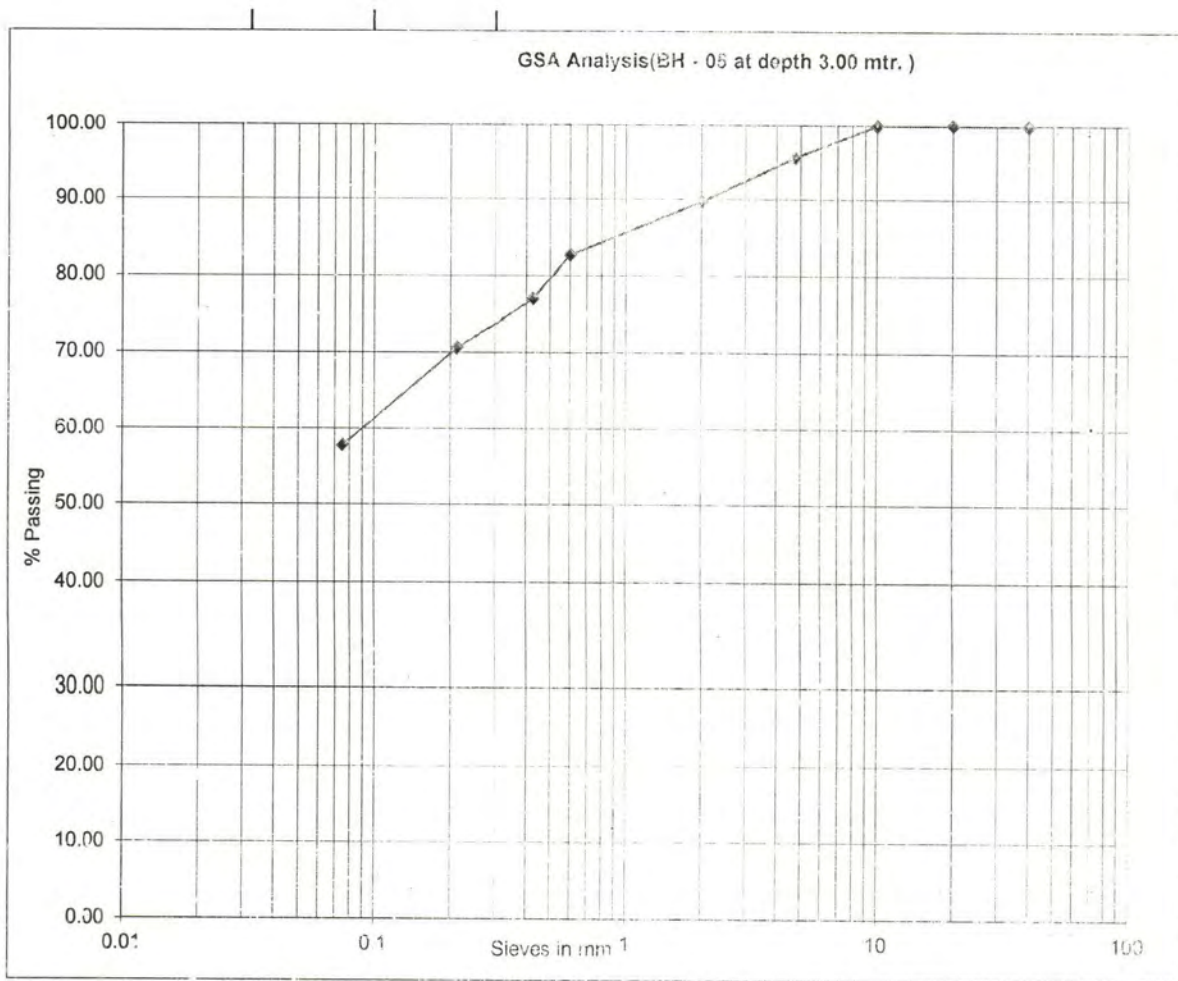
BH - 05

Nature : - YELLOW SOIL

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	1.948	gm/cc
2	Moisture Content		13.83	%
3	Atterberg's Limit of Soil			
a)	LL		46	%
b)	PL		28	
c)	PI		18	
4	Grain Size Analyses			
a)	Gravel		4.39	%
b)	Sand		57.83	%
c)	Silt + Clay		57.78	%
5	C Value (Kg/Cm ²)		0.45	Kg/cm ²
6	ϕ value of Soil (%)		12.00	%
7	Allowable Bearing Capacity			
a)	Depth 3.00 Mtr.		15.26	T/M ²



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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 3.000m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 19.48kN/m³.

Bulk density (W) of soil below Foundation base : 19.48kN/m³.

Cohesion C' : 30.00kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.230	lc = 1.000
Sq = 1.200	Dq = 1.000	lq = 1.000
Sg = 0.800	Dg = 1.000	lg = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 58.44kN/m².

****For local shear Failure****

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot lc + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot lq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot lg \cdot W'$
 Effective angle of internal friction(ϕ') : 8.07

Bearing capacity factors.

N'_c = 7.55

N'_q = 2.07

N'_g = 0.87

Thus $Q_{ult_n} = 457.93 \text{ kN/m}^2$.

Allowable Bearing Capacity (Q_{ns}) = 15.26 T/m².



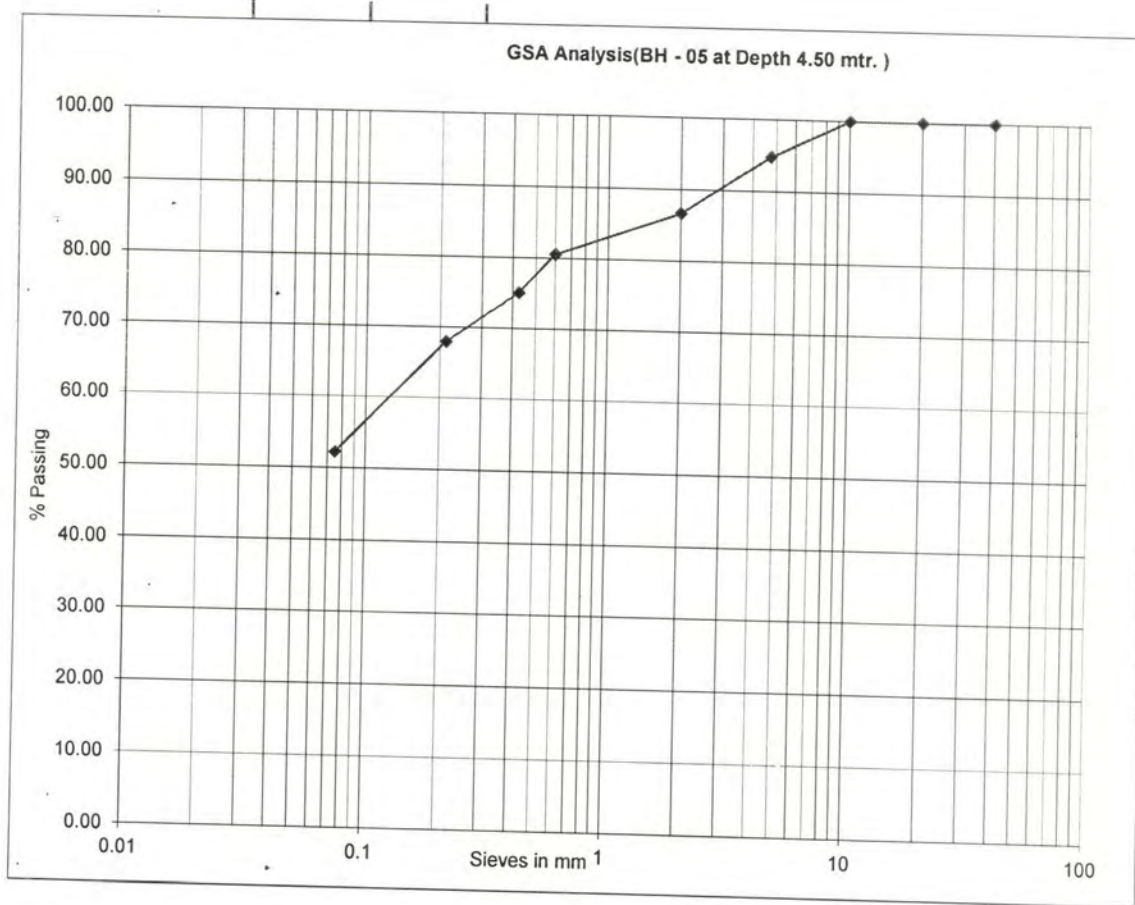
BH - 05

Nature : - YELLOW SOIL

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	1.959	gm/cc
2	Moisture Content		13.33	%
3	Atterberg's Limit of Soil			
a)	LL		43	%
b)	PL		29	
c)	PI		14	
4	Grain Size Analyses			
a)	Gravel		5.18	%
b)	Sand		42.58	%
c)	Silt + Clay		52.24	%
5	C Value (Kg/Cm ²)		0.43	Kg/cm ²
6	Φ value of Soil (°)		13.70	°
7	Allowable Bearing Capacity			
8	Length 4.50 Mtr.		19.91	T/M ²

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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 4.500m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 19.59kN/m³.

Bulk density (W) of soil below Foundation base : 19.59kN/m³.

Cohesion C' : 28.67kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.353	lc = 1.000
Sq = 1.200	Dq = 1.000	lq = 1.000
Sg = 0.800	Dg = 1.000	lg = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 88.16kN/m².

****For local shear Failure****

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot lc + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot lq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot lg \cdot W'$
Effective angle of internal friction(phi') : 9.23

Bearing capacity factors

N'_c = 8.02

N'_q = 2.30

N'_g = 1.07

Thus $Q_{ult_n} = 567.42 \text{ kN/m}^2$.

Allowable Bearing Capacity (Q_{ns}) = 18.91 T/m².



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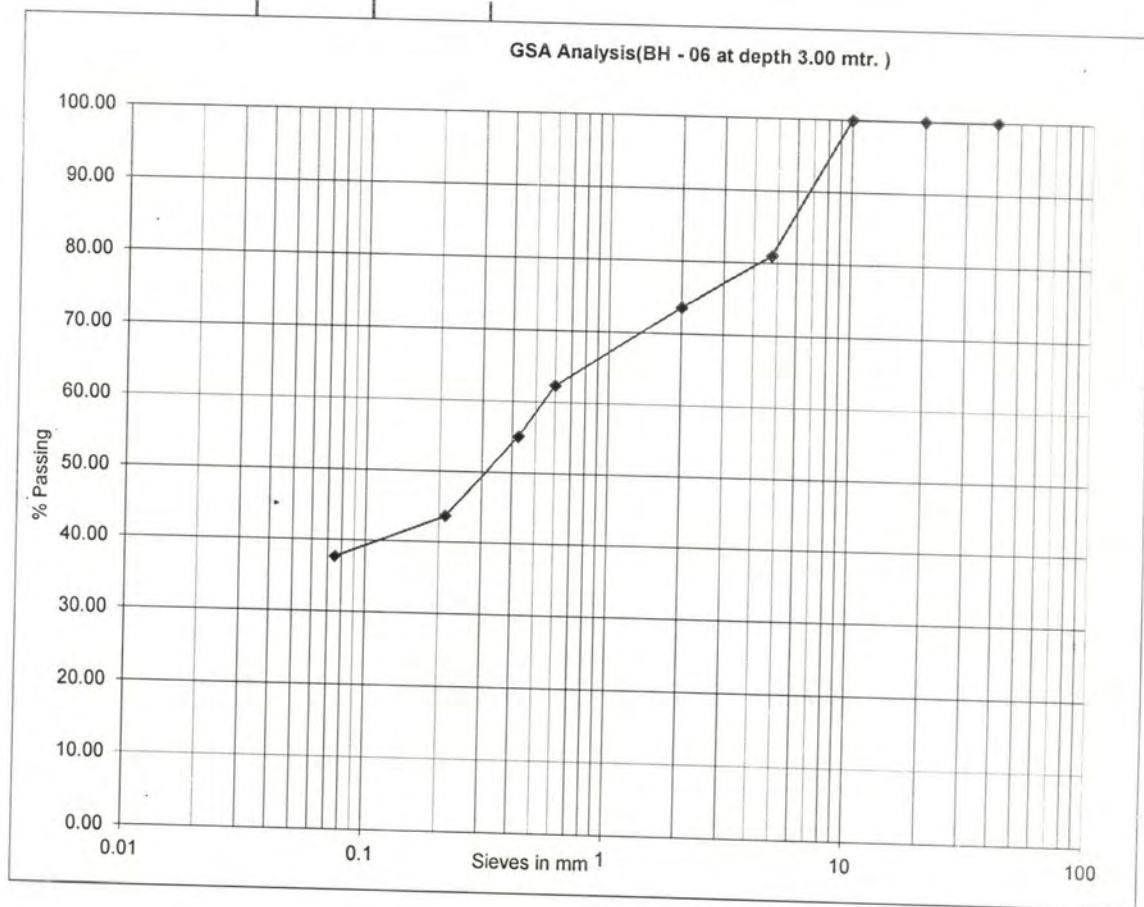


BH - 06Nature : - MOORUM

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	2.057	gm/cc
2	Moisture Content		12.06	%
3	Atterberg's Limit of Soil			
a)	LL		37	%
b)	PL		27	
c)	PI		10	
4	Grain Size Analyses			
a)	Gravel		18.97	%
b)	Sand		43.35	%
c)	Silt + Clay		37.68	%
5	C Value (Kg/Cm ²)		0.38	Kg/cm ²
6	Φ value of Soil (°)		16.00	°
7	Allowable Bearing Capacity			
a)	Depth 3.00 Mtr.		17.79	T/M ²

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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 3.000m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 20.57kN/m³.

Bulk density (W) of soil below Foundation base : 20.57kN/m³.

Cohesion C' : 25.33kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.242	Ic = 1.000
Sq = 1.200	Dq = 1.121	Iq = 1.000
Sg = 0.800	Dg = 1.121	Ig = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 61.71kN/m².

****For local shear Failure****

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot Ic + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot Iq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot Ig \cdot W'$
 Effective angle of internal friction(phi') : 10.82

Bearing capacity factors

N'_c = 8.72

N'_q = 2.67

N'_g = 1.40

Thus $Q_{ult_n} = 533.71 \text{ kN/m}^2$.

Allowable Bearing Capacity (Qns) = 17.79 T/m².



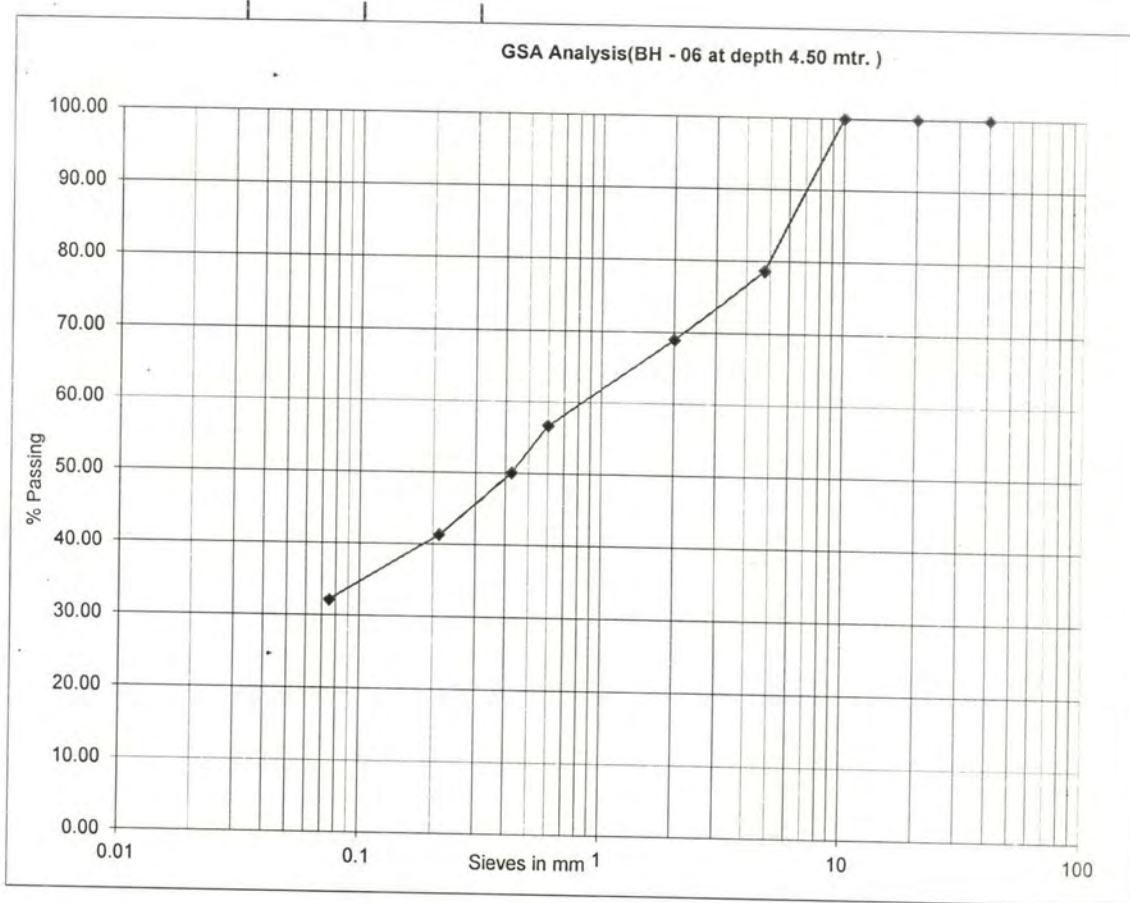
BH - 06

Nature : - MOORUM

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	2.124	gm/cc
2	Moisture Content		11.54	%
3	Atterberg's Limit of Soil			
a)	LL		35	%
b)	PL		26	
c)	PI		9	
4	Grain Size Analyses			
a)	Gravel		21.35	%
b)	Sand		46.50	%
c)	Silt + Clay		32.15	%
5	C Value (Kg/Cm ²)		0.35	Kg/cm ²
6	Φ value of Soil (°)		17.20	°
7	Allowable Bearing Capacity			
a)	Depth 4.50 Mtr.		22.75	T/M ²

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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 4.500m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 21.24kN/m³.

Bulk density (W) of soil below Foundation base : 21.24kN/m³.

Cohesion C' : 23.33kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.368	lc = 1.000
Sq = 1.200	Dq = 1.184	lq = 1.000
Sg = 0.800	Dg = 1.184	lg = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 95.58kN/m².

****For local shear Failure****

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot lc + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot lq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot lg \cdot W'$
 Effective angle of internal friction(ϕ') : 11.66

Bearing capacity factors

N'_c = 9.12

N'_q = 2.88

N'_g = 1.60

Thus $Q_{ult_n} = 682.41 \text{ kN/m}^2$.

Allowable Bearing Capacity (Q_{ns}) = 22.75 T/m².



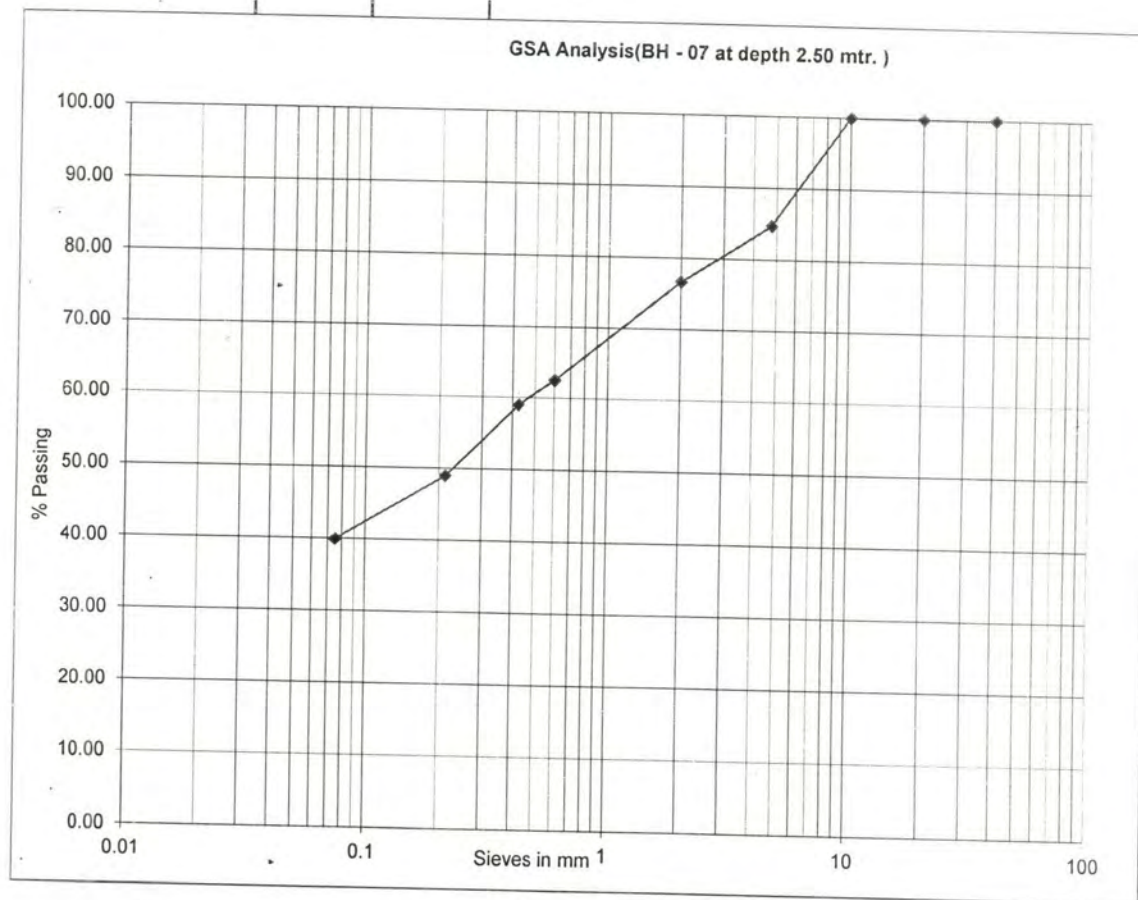
SUBMITTED BY MINISIPAI TEST LABS (b) (6) (1)

BH - 07**Nature : - SOFT MOORUM**

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	2.024	gm/cc
2	Moisture Content		12.35	%
3	Atterberg's Limit of Soil			
a)	LL		38	%
b)	PL		29	
c)	PI		9	
4	Grain Size Analyses			
a)	Gravel		15.27	%
b)	Sand		44.79	%
c)	Silt + Clay		39.94	%
4	C Value (Kg/Cm ²)		0.40	Kg/cm ²
5	Φ value of Soil (°)		15.50	°
6	Allowable Bearing Capacity			
a)	Depth 2.50 Mtr.		16.58	T/M ²



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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 2.500m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 20.24kN/m³.

Bulk density (W) of soil below Foundation base : 20.24kN/m³.

Cohesion C' : 26.67kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.200	Ic = 1.000
Sq = 1.200	Dq = 1.100	Iq = 1.000
Sg = 0.800	Dg = 1.100	Ig = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 50.60kN/m².

****For local shear Failure****

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot Ic + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot Iq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot Ig \cdot W'$
 Effective angle of internal friction(phi') : 10.47

Bearing capacity factors

N'c = 8.56

N'q = 2.58

N'g = 1.32

Thus $Q_{ult_n} = 497.27 \text{ kN/m}^2$.

Allowable Bearing Capacity (Qns) = 16.58 T/m².

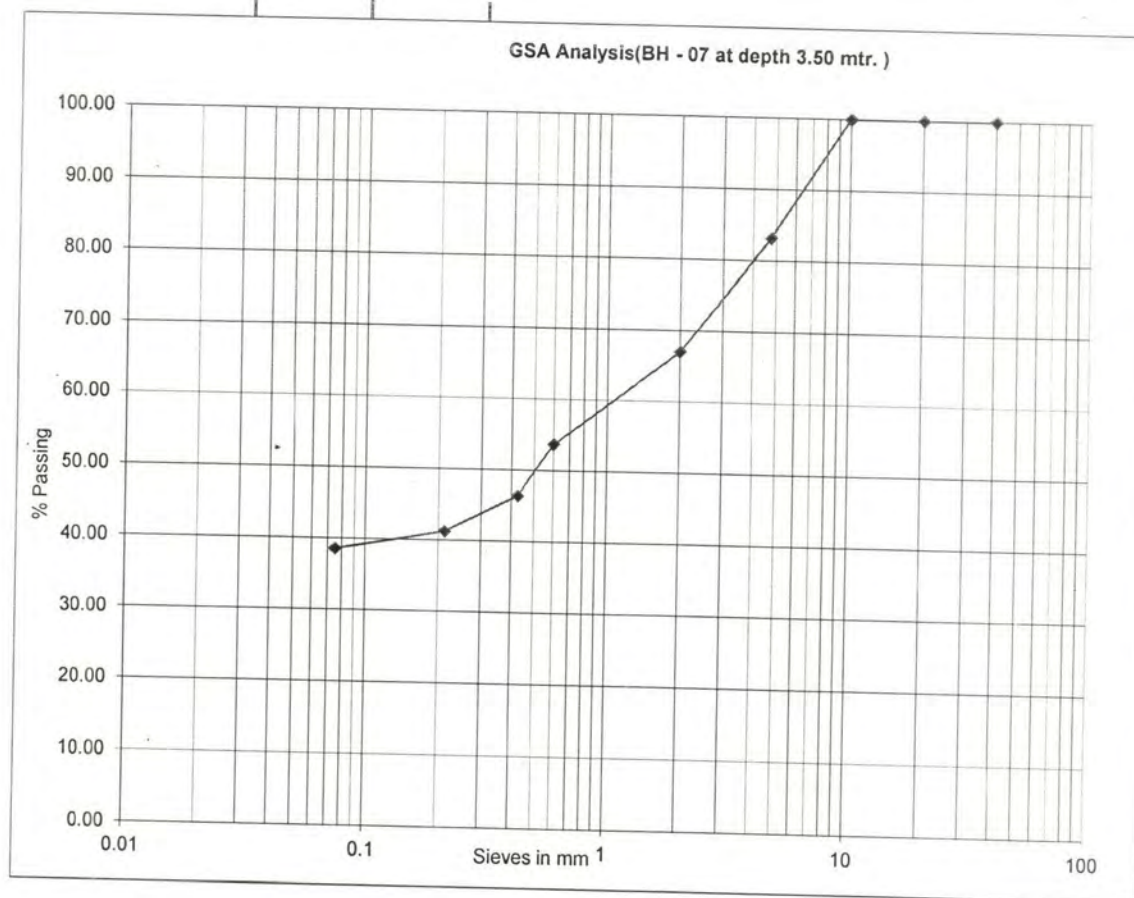


BH - 07Nature : - SOFT MOORUM

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	2.085	gm/cc
2	Moisture Content		12.19	%
3	Atterberg's Limit of Soil			
a)	LL		35	%
b)	PL		28	
c)	PI		7	
4	Grain Size Analyses			
a)	Gravel		16.86	%
b)	Sand		44.58	%
c)	Silt + Clay		38.56	%
5	C Value (Kg/Cm ²)		0.38	Kg/cm ²
6	Φ value of Soil (°)		17.10	°
7	Allowable Bearing Capacity			
a)	Depth 3.50 Mtr.		20.57	T/M ²

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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 3.500m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 20.89kN/m³.

Bulk density (W) of soil below Foundation base : 20.89kN/m³.

Cohesion C' : 25.33kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.286	lc = 1.000
Sq = 1.200	Dq = 1.143	lq = 1.000
Sg = 0.800	Dg = 1.143	lg = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 73.12kN/m².

******For local shear Failure******

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot lc + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot lq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot lg \cdot W'$
 Effective angle of internal friction(phi') : 11.59

Bearing capacity factors

N'_c = 9.08

N'_q = 2.86

N'_g = 1.58

Thus $Q_{ult_n} = 617.03 \text{ kN/m}^2$.

Allowable Bearing Capacity (Q_{ns}) = 20.57 T/m².

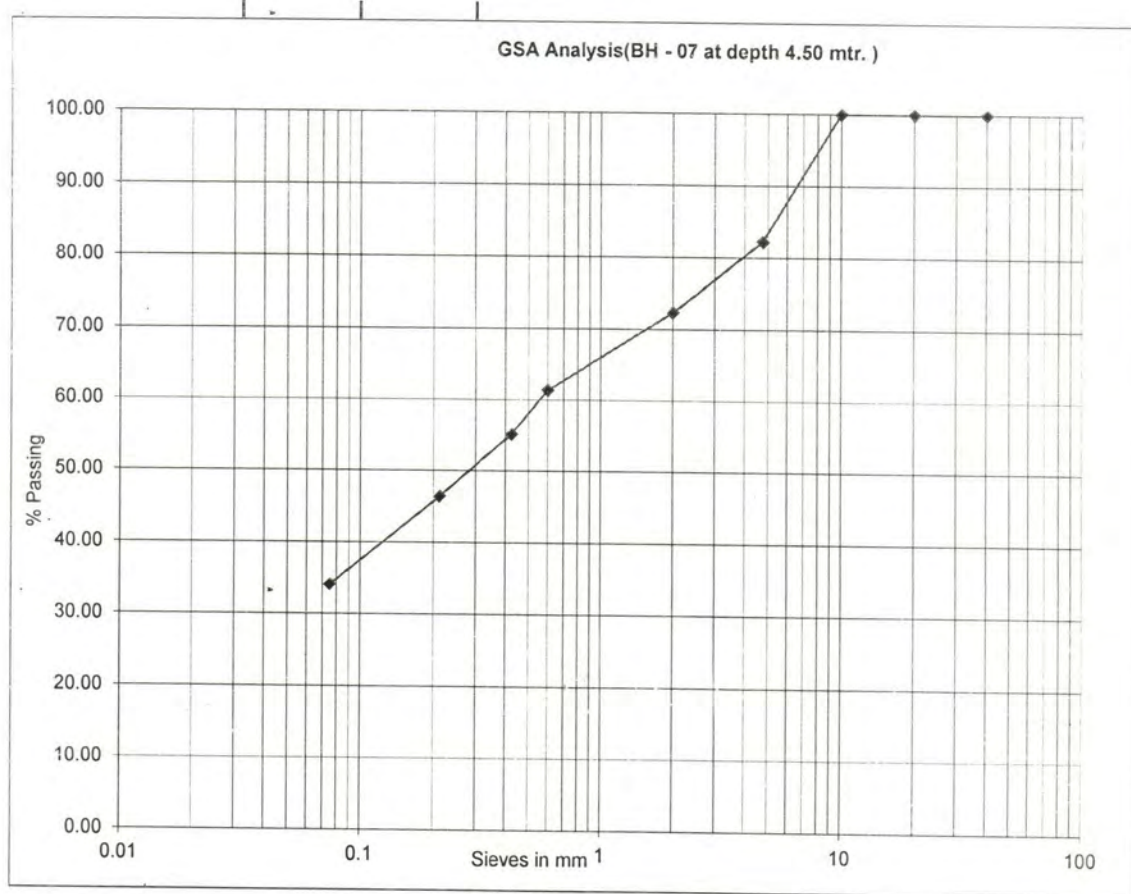


BH - 07Nature : - SOFT MOORUM

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	2.110	gm/cc
2	Moisture Content		11.89	%
3	Atterberg's Limit of Soil			
a)	LL		33	%
b)	PL		28	
c)	PI		5	
4	Grain Size Analyses			
a)	Gravel		17.78	%
b)	Sand		48.11	%
c)	Silt + Clay		34.11	%
5	C Value (Kg/Cm ²)		0.36	Kg/cm ²
6	Φ value of Soil (°)		18.90	°
7	Allowable Bearing Capacity			
a)	Depth 4.50 Mtr.		25.89	T/M ²

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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 4.500m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 21.10kN/m³.

Bulk density (W) of soil below Foundation base : 21.10kN/m³.

Cohesion C' : 24.00kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.376	lc = 1.000
Sq = 1.200	Dq = 1.188	lq = 1.000
Sg = 0.800	Dg = 1.188	lg = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 94.95kN/m².

****For local shear Failure****

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot lc + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot lq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot lg \cdot W'$
 Effective angle of internal friction(phi) : 12.86

Bearing capacity factors

N'c = 9.73

N'q = 3.22

N'g = 1.93

Thus $Q_{ult_n} = 776.75 \text{ kN/m}^2$.

Allowable Bearing Capacity (Qns) = 25.89 T/m².



MARSHAL TEST LABS (I) PVT. LTD.,																	
BORE LOG DETAILS OF SOIL INVESTIGATION																	
CONTRACTOR	The DGM AAI, DABH, Airport, Indore.																
PROJECT	Soil Investigation Work for Development of UJJAIN - AIRPORT																
LOCATION	L9																
BORE LOG NO.	08																
Depth Below G.L. (Mtr.)	Profile	Description of Strata	Thickness of Layer (Mtr.)	Standard Penetration Test		Depth at Which test is conducted (Mtr.)	Laboratory Test Results										
				Depth in Mtr.	N Value		Grain Size Analysis			Atterberg's Limit			Free Swell Index (%)	Shear Test		ALLOWABLE SAFE BEARING CAPACITY T/M2	
0.00 to 2.10		BLACK COTTON + YELLOW SOIL	2.10	1.5	13	---	1.811	17.56	0	4.14	95.86	58	30	28	57.4		---
2.10 to 2.50		YELLOW SOIL	0.40	---	---	---	---	---	---	---	---	---	---	---	---	---	---
2.50 to 6.00		MOORUM	3.50	3.00	>50	3.0	2.039	12.72	13.06	47.73	39.21	38	28	10	30.56	0.39	15.6
				4.50	---	4.5	2.089	12.21	16.38	49.46	34.16	36	27	9	29.73	0.37	17.8
				6.00	---	6.0	2.127	11.68	18.82	50.65	30.53	32	24	8	25.97	0.35	19
				---	---	---	---	---	---	---	---	---	---	---	---	---	---
Borehole Terminated @ 6.00 M																	



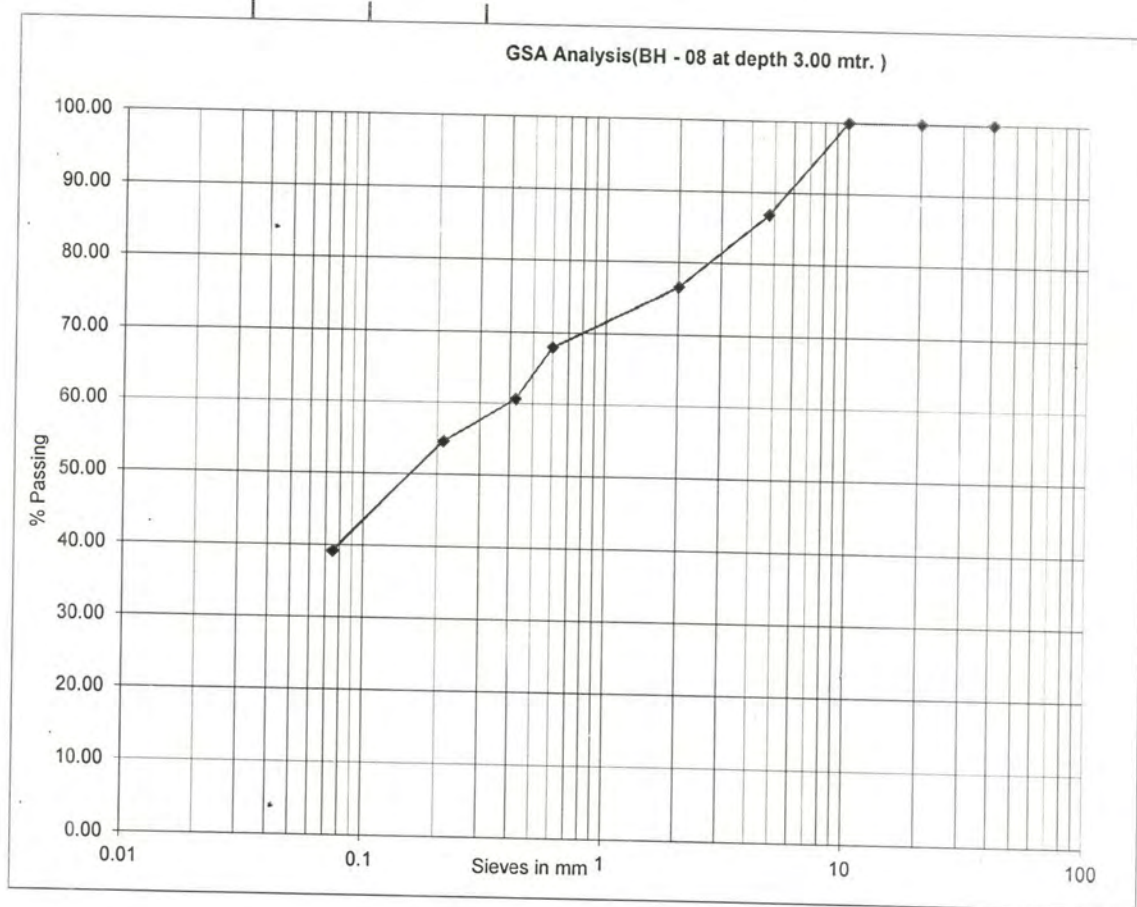
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BH - 08Nature : - MOORUM

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	2.039	gm/cc
2	Moisture Content		12.72	%
3	Atterberg's Limit of Soil			
a)	LL		38	%
b)	PL		28	
c)	PI		10	
4	Grain Size Analyses			
a)	* Gravel		13.06	%
b)	Sand		47.73	%
c)	Silt + Clay		39.21	%
5	C Value (Kg/Cm ²)		0.39	Kg/cm ²
6	Φ value of Soil (°)		15.60	
7	Allowable Bearing Capacity			
a)	Depth 3.00 Mtr.		17.61	T/M ²

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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 3.000m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 20.36kN/m³.

Bulk density (W) of soil below Foundation base : 20.36kN/m³.

Cohesion C' : 26.00kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.241	lc = 1.000
Sq = 1.200	Dq = 1.120	lq = 1.000
Sg = 0.800	Dg = 1.120	lg = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 61.08kN/m².

****For local shear Failure****

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot lc + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot lq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot lg \cdot W'$
 Effective angle of internal friction(ϕ') : 10.54

Bearing capacity factors

N'_c = 8.59

N'_q = 2.60

N'_g = 1.34

Thus $Q_{ult_n} = 528.24 \text{ kN/m}^2$.

Allowable Bearing Capacity (Q_{ns}) = 17.61 T/m².

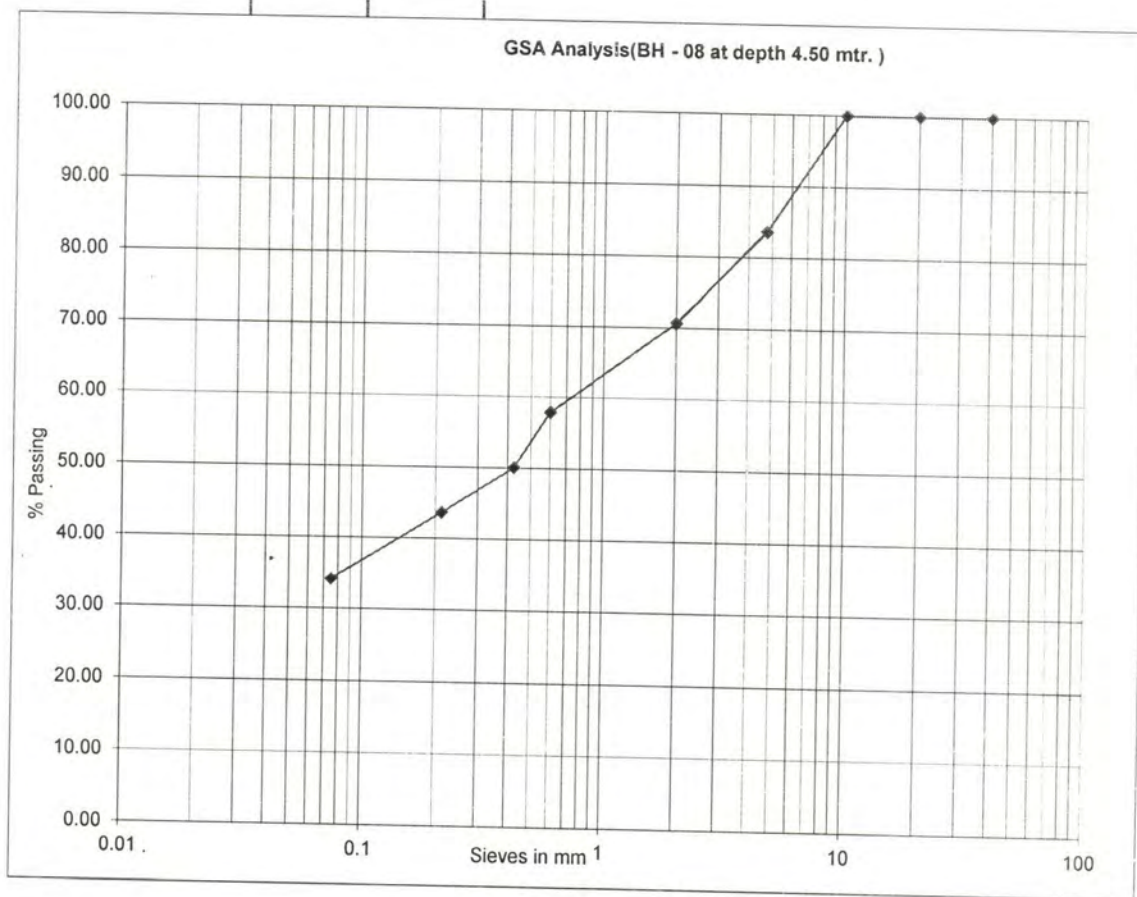


BH - 08Nature : - MOORUM

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	2.089	gm/cc
2	Moisture Content		12.21	%
3	Atterberg's Limit of Soil			
a)	LL		36	%
b)	PL		27	
c)	PI		9	
4	Grain Size Analyses			
a)	Gravel		16.38	%
b)	Sand		49.46	%
c)	Silt + Clay		34.16	%
5	C Value (Kg/Cm ²)		0.37	Kg/cm ²
6	Φ value of Soil (°)		17.80	°
7	Allowable Bearing Capacity			
a)	Depth 4.50 Mtr.		24.27	T/M ²

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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 4.500m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 20.89kN/m³.

Bulk density (W) of soil below Foundation base : 20.89kN/m³.

Cohesion C' : 24.67kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.371	lc = 1.000
Sq = 1.200	Dq = 1.186	lq = 1.000
Sg = 0.800	Dg = 1.186	lg = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 94.00kN/m².

******For local shear Failure******

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot lc + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot lq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot lg \cdot W'$
 Effective angle of internal friction(ϕ') : 12.08

Bearing capacity factors

N'_c = 9.33

N'_q = 3.00

N'_g = 1.71

Thus $Q_{ult_n} = 728.07 \text{ kN/m}^2$.

Allowable Bearing Capacity (Q_{ns}) = 24.27 T/m².



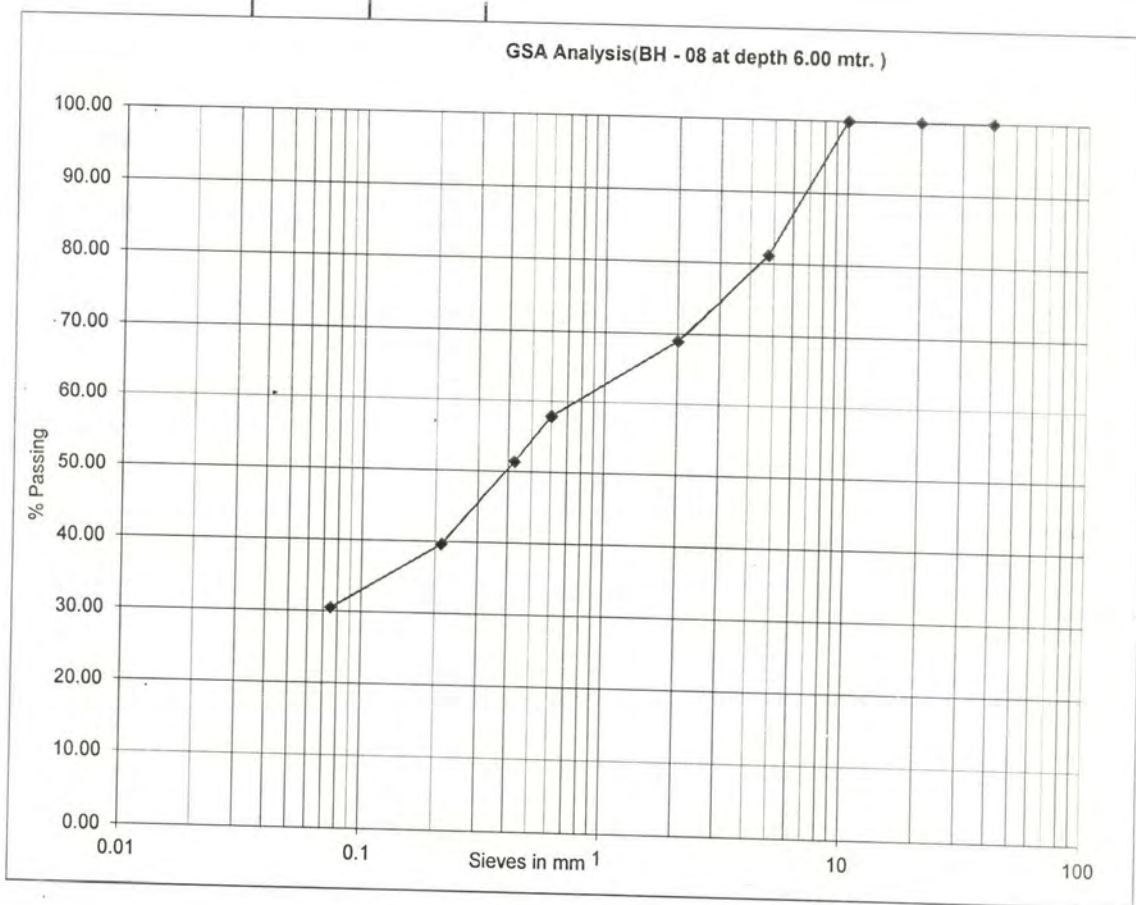
BH - 08

Nature : - MOORUM

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	2.127	gm/cc
2	Moisture Content		11.68	%
3	Atterberg's Limit of Soil			
a)	LL		32	%
b)	PL		24	
c)	PI		8	
4	Grain Size Analyses			
a)	Gravel		18.82	%
b)	Sand		50.65	%
c)	Silt + Clay		30.53	%
5	C Value (Kg/Cm ²)		0.35	Kg/cm ²
6	Φ value of Soil (°)		19.00	°
7	Allowable Bearing Capacity			
a)	Depth 6.00 Mtr.		31.25	T/M ²

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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 6.000m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 21.27kN/m³.

Bulk density (W) of soil below Foundation base : 21.27kN/m³.

Cohesion C' : 23.33kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.502	lc = 1.000
Sq = 1.200	Dq = 1.251	lq = 1.000
Sg = 0.800	Dg = 1.251	lg = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 127.62kN/m².

****For local shear Failure****

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot lc + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot lq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot lg \cdot W'$
 Effective angle of internal friction(ϕ') : 12.93

Bearing capacity factors

N'_c = 9.77

N'_q = 3.24

N'_g = 1.95

Thus $Q_{ult_n} = 937.36 \text{ kN/m}^2$.

Allowable Bearing Capacity (Q_{ns}) = 31.25 T/m².



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BORE LOG DETAILS OF SOIL INVESTIGATION																													
CONTRACTOR		The DGM AAI, DABH, Airport, Indore.																											
PROJECT		Soil Investigation Work for Development of UJJAIN - AIRPORT																											
LOCATION		L6																											
BORE LOG NO.		09																											
Depth Below G.L. (Mtr.)	Profile	Description of Strata	Thickness of Layer (Mtr.)	Standard Penetration Test		Depth at Which test is conducted (Mtr.)	Laboratory Test Results																						
				Depth in Mtr.	N Value		Grain Size Analysis			Atterberg's Limit			Shear Test		ALLOWABLE SAFE BEARING CAPACITY T/M2														
0.00 to 1.50		BLACK COTTON	1.50	1.5	11	----	Bulk Density (gm/cc)	1.795	Moisture Content (%)		17.55	Gravel (%)	0	Sand (%)		4.06	Silt + Clay (%)	95.94	LL (%)	57	PL (%)	31	PI (%)	26	Free Swell Index (%)	56.3	C Value (Kg/Cm ²)	----	Φ value of Soil (°)
1.50 to 4.50		YELLOW SOIL	3.00	3.0	27	3.00	2.115	1.938	13.75		10.24	7.05	36.27	56.68	44	29	15	41.54	0.45	12.60	15.76								
4.50 to 6.00		MOORUM	1.50	4.5	>50	5.00	2.115	10.24	13.24		62.44	24.32	29	23	6	25.33	0.36	17.60	25.28										
Borehole Terminated @ 6.00 M																													

Borehole Terminated @ 6.00 M



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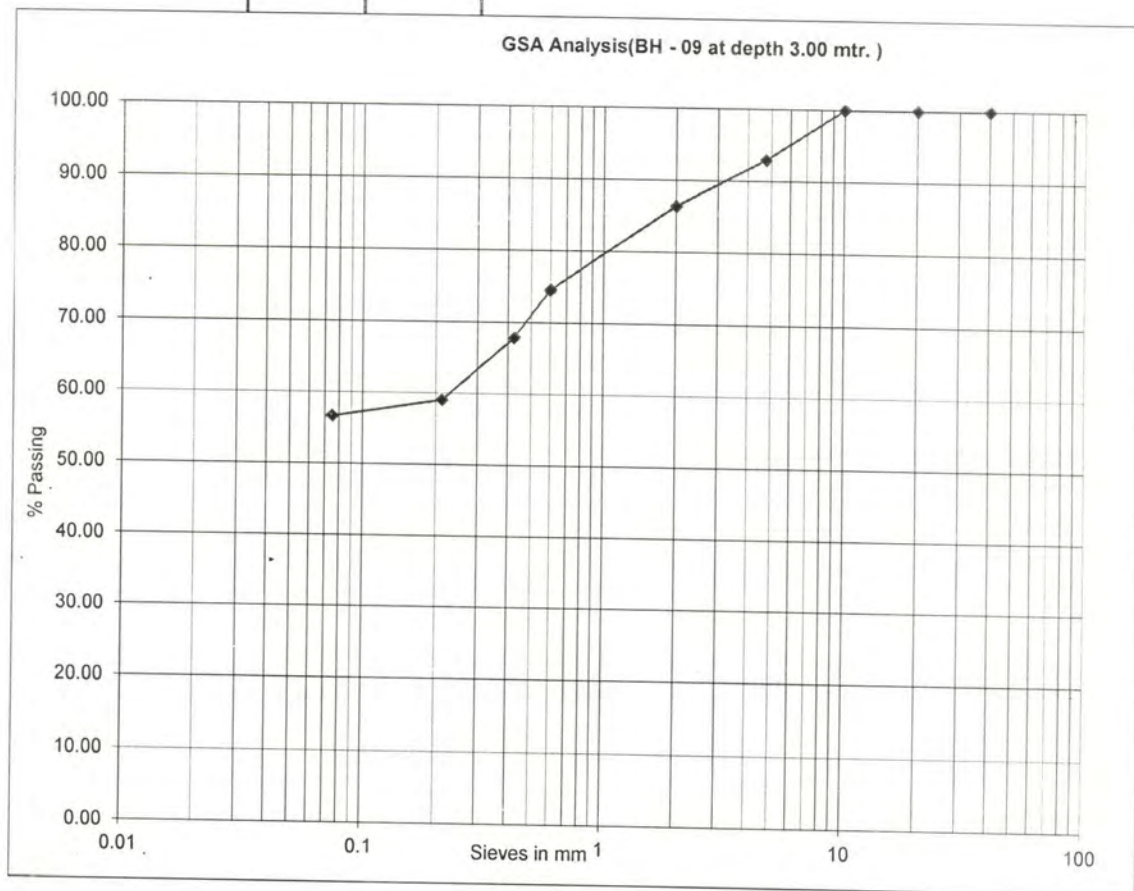
BH - 09

Nature : - YELLOW SOIL

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	1.938	gm/cc
2	Moisture Content		13.75	%
3	Atterberg's Limit of Soil			
a)	LL		44	%
b)	PL		29	
c)	PI		15	
4	Grain Size Analyses			
a)	Gravel		7.05	%
b)	Sand		36.27	%
c)	Silt + Clay		56.68	%
5	C Value (Kg/Cm ²)		0.45	Kg/cm ²
6	Φ value of Soil (°)		12.60	°
7	Allowable Bearing Capacity			
a)	Depth 3.00 Mtr.		15.76	T/M ²

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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 3.000m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 19.38kN/m³.

Bulk density (W) of soil below Foundation base : 19.38kN/m³.

Cohesion C' : 30.00kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.232	lc = 1.000
Sq = 1.200	Dq = 1.000	lq = 1.000
Sg = 0.800	Dg = 1.000	lg = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 58.14kN/m².

******For local shear Failure******

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot lc + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot lq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot lg \cdot W'$
 Effective angle of internal friction(ϕ') : 8.48

Bearing capacity factors

N'_c = 7.71

N'_q = 2.15

N'_g = 0.94

Thus $Q_{ult_n} = 472.71 \text{ kN/m}^2$.

Allowable Safe bearing capacity (Q_{ns}) = 15.76 T/m².

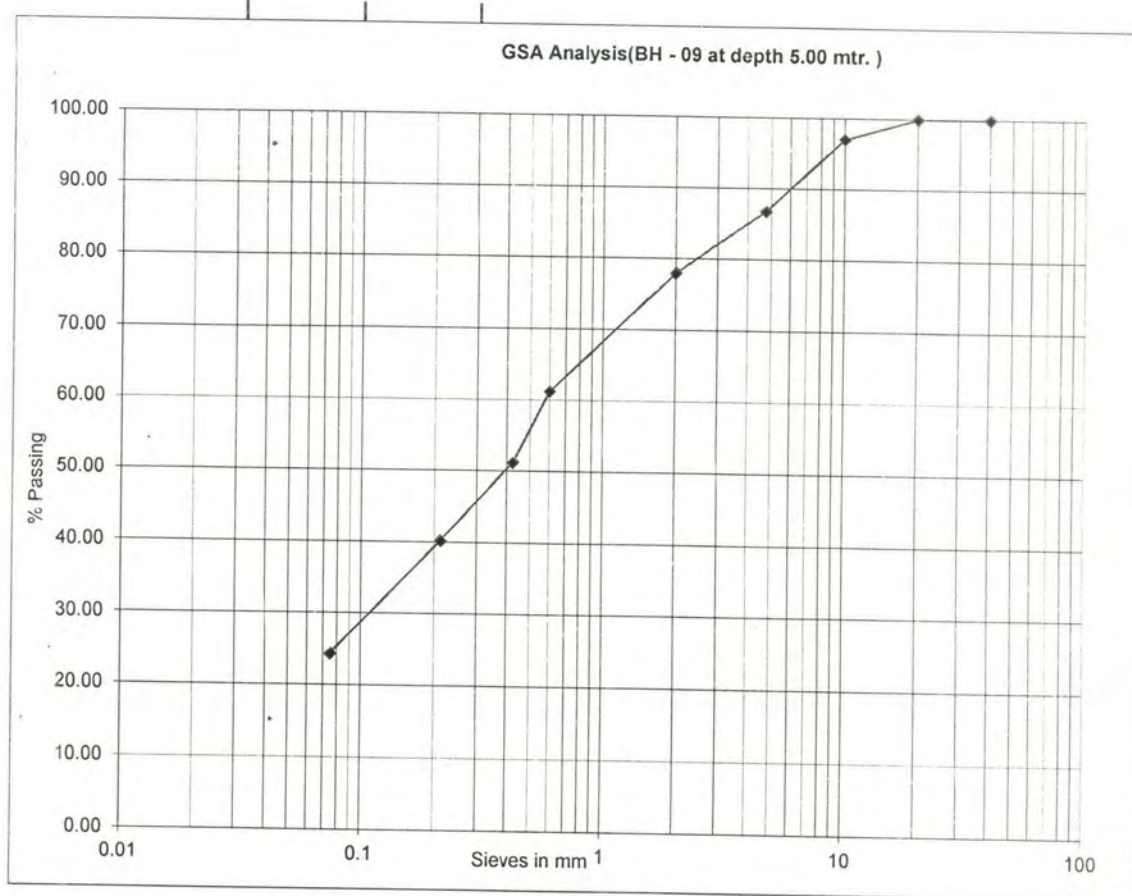


BH - 09Nature : - MOORUM

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	2.115	gm/cc
2	Moisture Content		10.24	%
3	Atterberg's Limit of Soil			
a)	LL		29	%
b)	PL		23	
c)	PI		6	
4	Grain Size Analyses			
a)	Gravel		13.24	%
b)	Sand		62.44	%
c)	Silt + Clay		24.32	%
5	C Value (Kg/Cm ²)		0.36	Kg/cm ²
6	Φ value of Soil (°)		17.60	°
7	Allowable Bearing Capacity			
a)	Depth 5.00 Mtr.		25.28	T/M ²

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****Sample calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 5.000m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 21.15kN/m³.

Bulk density (W) of soil below Foundation base : 21.15kN/m³.

Cohesion C' : 24.00kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.411	lc = 1.000
Sq = 1.200	Dq = 1.206	lq = 1.000
Sg = 0.800	Dg = 1.206	lg = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 105.75kN/m².

******For local shear Failure******

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot lc + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot lq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot lg \cdot W'$
 Effective angle of internal friction(ϕ') : 11.94

Bearing capacity factors

N'_c = 9.26

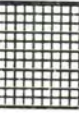



N'_q = 2.96

N'_g = 1.67

Thus $Q_{ult_n} = 758.43 \text{ kN/m}^2$.

Allowable Safe bearing capacity (Q_{ns}) = 25.28 T/m².



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BORE LOG DETAILS OF SOIL INVESTIGATION															
CONTRACTOR	The DGM AAI, DABH, Airport, Indore.														
PROJECT	Soil Investigation Work for Development of UJJAIN - AIRPORT														
LOCATION	L1														
BORE LOG NO.	10														
Depth Below G.L. (Mtr.)	Profile	Description of Strata	Thickness of Layer (Mtr.)	Standard Penetration Test		Depth at Which test is conducted (Mtr.)	Laboratory Test Results								
				Depth in Mtr.	N Value		Grain Size Analysis			Atterberg's Limit			Shear Test		ALLOWABLE SAFE BEARING CAPACITY T/M2
0.00 to 0.70		BITUMINOUS + MOORUM	0.70	----	----	----	----	----	----	----	----	----	----	----	----
0.70 to 1.50		BLACK COTTON	0.80	1.5	14	----	----	0	----	----	27	----	----	----	----
1.50 to 3.00		YELLOW SOIL	1.50	3.0	>50	2.80	1.950	13.32	8.86	36.75	54.39	43	28	15	14.93
3.00 to 6.00		MOORUM	3.00	4.5	----	5.00	2.108	10.72	14.16	58.06	27.78	30	22	8	23.26
				6.0	----	----	----	----	----	----	----	----	----	----	----

Borehole Terminated @ 6.00 M



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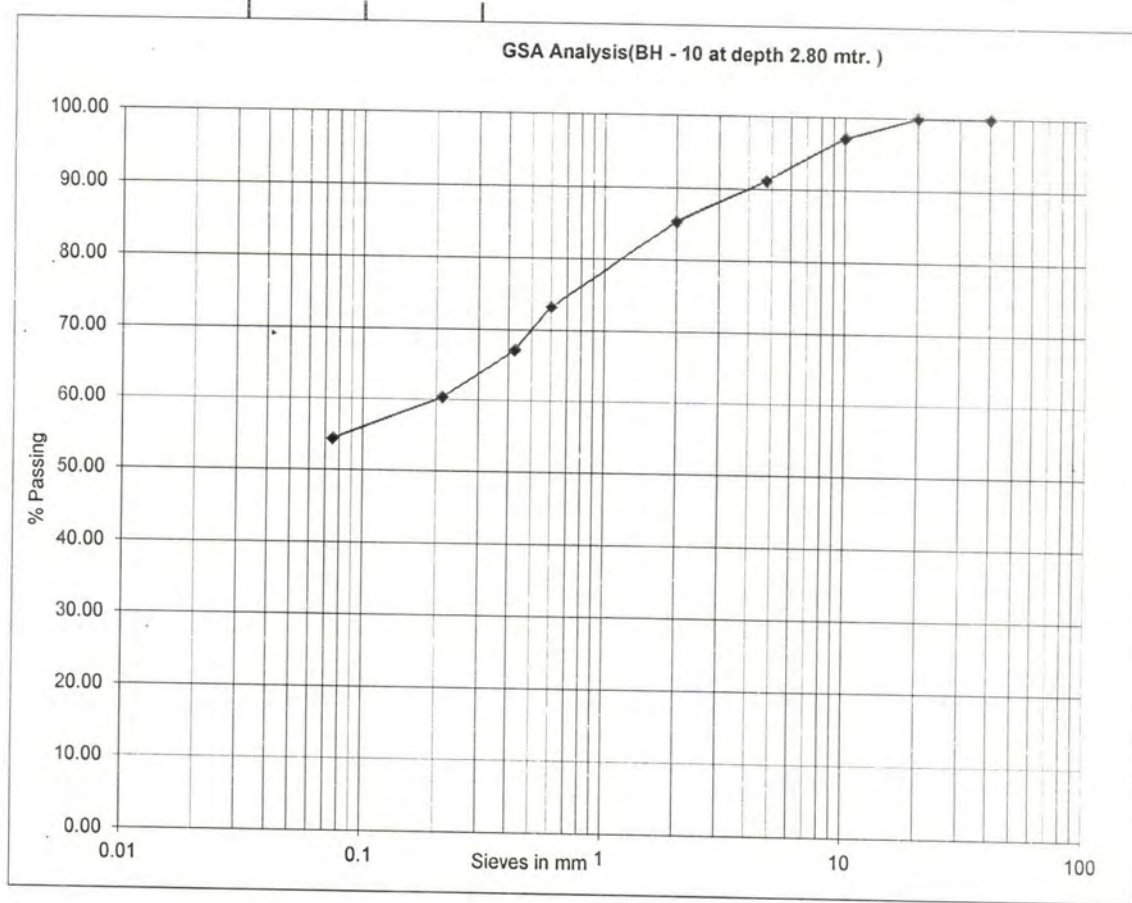
BH - 10

Nature : - YELLOW SOIL

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	1.950	gm/cc
2	Moisture Content		13.32	%
3	Atterberg's Limit of Soil			
a)	LL		43	%
b)	PL		28	
c)	PI		15	
4	Grain Size Analyses			
a)	Gravel		8.86	%
b)	Sand		36.75	%
c)	Silt + Clay		54.39	%
5	C Value (Kg/Cm ²)		0.44	Kg/cm ²
6	Φ value of Soil (°)		12.30	°
7	Allowable Bearing Capacity			
a)	Depth 2.80 Mtr.		14.93	T/M ²



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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 2.800m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 19.50kN/m³.

Bulk density (W) of soil below Foundation base : 19.50kN/m³.

Cohesion C' : 29.33kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.216	lc = 1.000
Sq = 1.200	Dq = 1.000	lq = 1.000
Sg = 0.800	Dg = 1.000	lg = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 54.60kN/m².

****For local shear Failure****

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot lc + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot lq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot lg \cdot W'$
 Effective angle of internal friction(ϕ') : 8.27

Bearing capacity factors

N'_c = 7.63

N'_q = 2.11

N'_g = 0.90

Thus $Q_{ult_n} = 447.79 \text{ kN/m}^2$.

Allowable Safe bearing capacity (Q_{ns}) = 14.93 T/m².

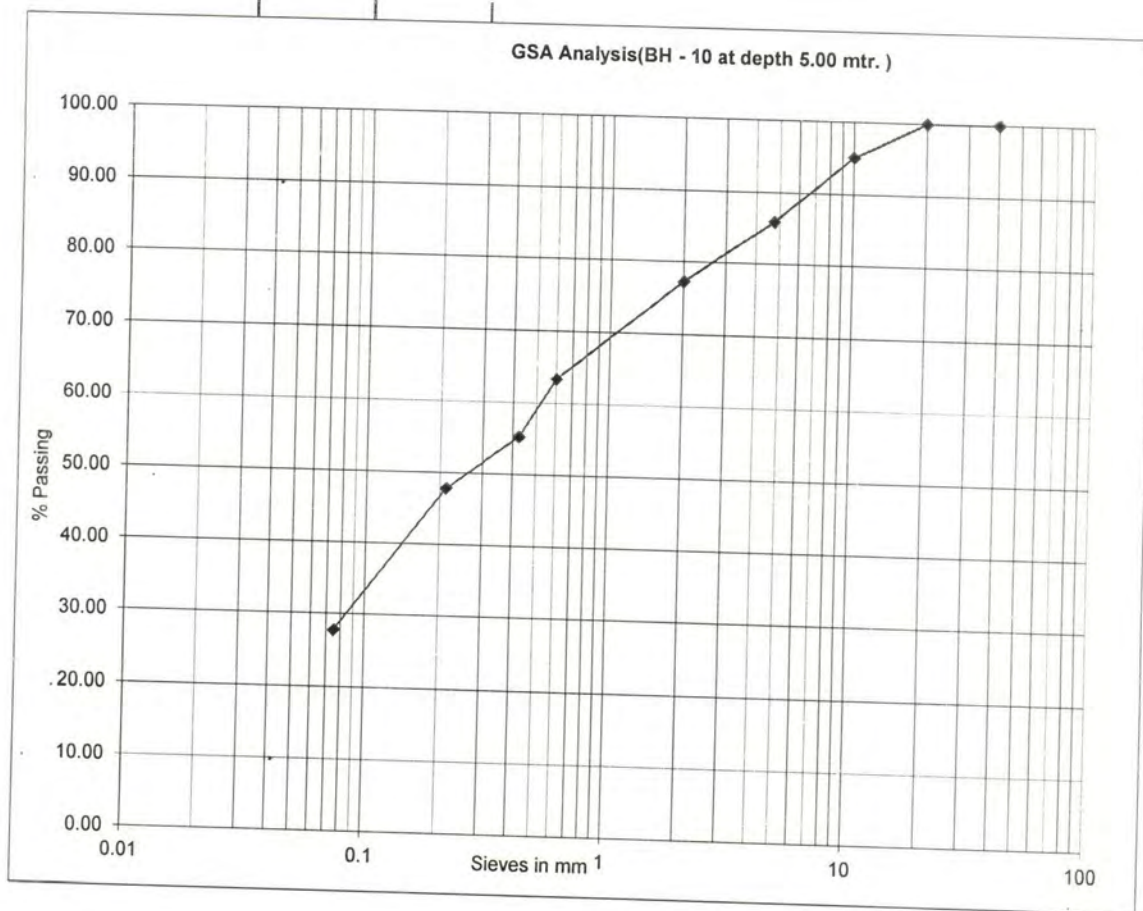


BH - 09Nature : - MOORUM

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	2.108	gm/cc
2	Moisture Content		10.72	%
3	Atterberg's Limit of Soil			
a)	LL		30	%
b)	PL		22	
c)	PI		8	
4	Grain Size Analyses			
a)	Gravel		14.16	%
b)	Sand		58.06	%
c)	Silt + Clay		27.78	%
5	C Value (Kg/Cm ²)		0.37	Kg/cm ²
6	Φ value of Soil (°)		16.20	°
7	Allowable Bearing Capacity			
a)	Depth 5.00 Mtr.		23.26	T/M ²

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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 5.000m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 21.08kN/m³.

Bulk density (W) of soil below Foundation base : 21.08kN/m³.

Cohesion C' : 24.67kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.404	lc = 1.000
Sq = 1.200	Dq = 1.202	lq = 1.000
Sg = 0.800	Dg = 1.202	lg = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 105.40kN/m².

****For local shear Failure****

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot lc + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot lq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot lg \cdot W'$
 Effective angle of internal friction(phi) : 10.96

Bearing capacity factors

N'_c = 8.78

N'_q = 2.70

N'_g = 1.43

Thus $Q_{ult_n} = 697.72 \text{ kN/m}^2$.

Allowable Safe bearing capacity (Q_{ns}) = 23.26 T/m².

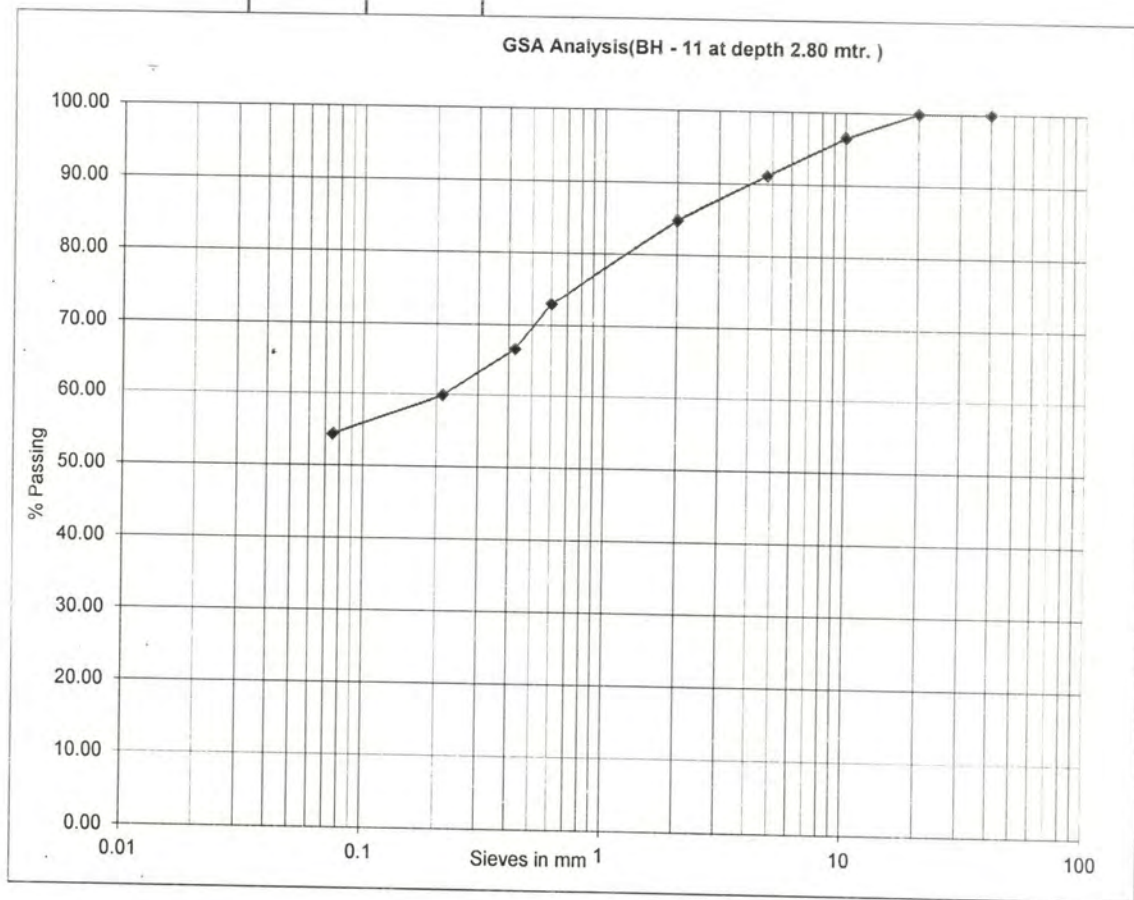


BH - 11Nature : - YELLOW SOIL

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	1.958	gm/cc
2	Moisture Content		13.32	%
3	Atterberg's Limit of Soil			
a)	LL		43	%
b)	PL		28	
c)	PI		15	
4	Grain Size Analyses			
a)	Gravel		8.86	%
b)	Sand		36.75	%
c)	Silt + Clay		54.39	%
5	C Value (Kg/Cm ²)		0.43	Kg/cm ²
6	Φ value of Soil (°)		13.50	°
7	Allowable Bearing Capacity			
a)	Depth 2.80 Mtr.		16.03	T/M ²

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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 3.000m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 19.58kN/m³.

Bulk density (W) of soil below Foundation base : 19.58kN/m³.

Cohesion C' : 28.67kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.235	Ic = 1.000
Sq = 1.200	Dq = 1.000	Iq = 1.000
Sg = 0.800	Dg = 1.000	Ig = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 58.74kN/m².

****For local shear Failure****

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot Ic + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot Iq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot Ig \cdot W'$
 Effective angle of internal friction(phi') : 9.09

Bearing capacity factors

N'_c = 7.96

N'_q = 2.27

N'_g = 1.05

Thus $Q_{ult_n} = 480.84 \text{ kN/m}^2$.

Allowable Safe bearing capacity (Q_{ns}) = 16.03 T/m².



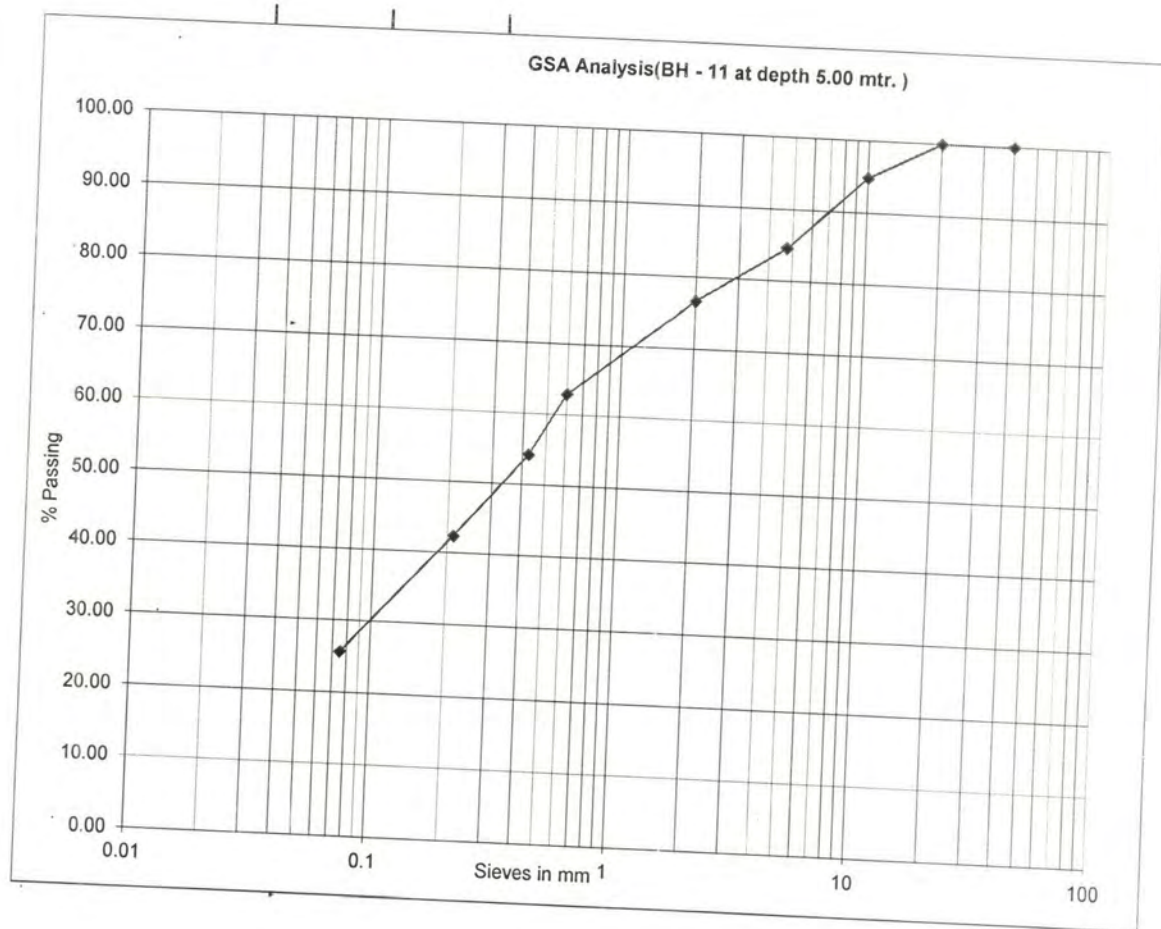
BH - 11

Nature : - MOORUM

S. No.	Name of Test	Test Method	Results	Unit
1	Bulk Density	As Per IS : Specification	2.153	gm/cc
2	Moisture Content		10.15	%
3	Atterberg's Limit of Soil			
a)	LL		27	%
b)	PL		21	
c)	PI		6	
4	Grain Size Analyses			
a)	Gravel		15.37	%
b)	Sand		58.99	%
c)	Silt + Clay		25.64	%
5	C Value (Kg/Cm ²)		0.35	Kg/cm ²
6	Φ value of Soil (°)		17.30	°
7	Allowable Bearing Capacity			
a)	Depth 5.00 Mtr.		24.59	T/M ²

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****Calculation for bearing capacity****

Failure mode - Local shear

Foundation type - ISOLATED SQUARE = 3.000m x 3.000m

Depth of foundation : 5.000m

Existing ground level : 0.000m

Ground water table level: -10.000m

Bulk density (W) of soil above Foundation base : 21.53kN/m³.Bulk density (W) of soil below Foundation base : 21.53kN/m³.Cohesion C' : 23.33kN/m²

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.300	Dc = 1.410	Ic = 1.000
Sq = 1.200	Dq = 1.205	Iq = 1.000
Sg = 0.800	Dg = 1.205	Ig = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 107.65kN/m².******For local shear Failure******

Ultimate Net B.C. = $Q_{ult_n} = C' \cdot N'_c \cdot Sc \cdot Dc \cdot Ic + q \cdot (N'_q - 1) \cdot Sq \cdot Dq \cdot Iq + 0.5 \cdot B \cdot W \cdot N'_g \cdot Sg \cdot Dg \cdot Ig \cdot W'$
 Effective angle of internal friction(ϕ') : 11.73

Bearing capacity factors

N'_c = 9.15N'_q = 2.90N'_g = 1.62Thus $Q_{ult_n} = 737.66 \text{ kN/m}^2$.Allowable Safe bearing capacity (Q_{ns}) = 24.59 T/m².

CONTRACTOR		The DGM AAI, DABH, Airport, Indore.		
PROJECT		Soil Investigation Work for Development of UJJAIN - AIRPORT		
S. No.	Name of Test	Test Method	Results	Unit
Location :- Pit No. 1 Colony Road (L-6) Depth 2.50 Mtr				
1	OMC	As Per IS : 2720 Part - 08	14.92	%
2	MDD		1.786	gm/cc
3	C.B. R. Value	As Per IS : 2720 Part - 16	4.43	%
Location :- Pit No. 2 Fly Ash Brick Plant (L-10) Depth 1.70 Mtr				
1	OMC	As Per IS : 2720 Part - 08	12.61	%
2	MDD		1.861	gm/cc
3	C.B. R. Value	As Per IS : 2720 Part - 16	17.72	%
Location :- Pit No. 3 Between L-6 to L10 (L-9) Depth 2.50 Mtr				
1	OMC	As Per IS : 2720 Part - 08	15.21	%
2	MDD		1.761	gm/cc
3	C.B. R. Value	As Per IS : 2720 Part - 16	3.99	%
Location :- Pit No. 4 Goshala Near Well LHS Side (L-11) Depth 2.50 Mtr				
1	OMC	As Per IS : 2720 Part - 08	13.21	%
2	MDD		1.846	gm/cc
3	C.B. R. Value	As Per IS : 2720 Part - 16	13.73	%
Location :- Pit No. 5 Goshala Near Well RHS Side (L-8) Depth 2.30 Mtr				
1	OMC	As Per IS : 2720 Part - 08	12.65	%
2	MDD		1.859	gm/cc
3	C.B. R. Value	As Per IS : 2720 Part - 16	14.17	%
Location :- Pit No. 6 Patel Land (L-7) Depth 2.40 Mtr				
1	OMC	As Per IS : 2720 Part - 08	15.31	%
2	MDD		1.789	gm/cc
3	C.B. R. Value	As Per IS : 2720 Part - 16	4.87	%
Location :- Pit No. 7 Colony Resa (P-1) Depth 2.50 Mtr				
1	OMC	As Per IS : 2720 Part - 08	15.67	%
2	MDD		1.799	gm/cc
3	C.B. R. Value	As Per IS : 2720 Part - 16	4.43	%
Location :- Pit No. 8 Resa Near Old Runway (P-2) Depth 2.50 Mtr				
1	OMC	As Per IS : 2720 Part - 08	14.92	%
2	MDD		1.806	gm/cc
3	C.B. R. Value	As Per IS : 2720 Part - 16	5.32	%



CONTRACTOR		The DGM AAI, DABH, Airport, Indore.		
PROJECT		Soil Investigation Work for Development of UJJAIN - AIRPORT		
S. No.	Name of Test	Test Method	Results	Unit
Location :- Pit No. 1 (L-1) Depth 2.50 Mtr				
1	OMC	As Per IS : 2720 Part - 08	14.32	%
2	MDD		1.789	gm/cc
3	C.B. R. Value	As Per IS : 2720 Part - 16	4.87	%
Location :- Pit No. 2 (L-2) Depth 2.60 Mtr				
1	OMC	As Per IS : 2720 Part - 08	14.53	%
2	MDD		1.770	gm/cc
3	C.B. R. Value	As Per IS : 2720 Part - 16	4.43	%
Location :- Pit No. 3 (L-3) Depth 2.70 Mtr				
1	OMC	As Per IS : 2720 Part - 08	13.89	%
2	MDD		1.791	gm/cc
3	C.B. R. Value	As Per IS : 2720 Part - 16	5.32	%
Location :- Pit No. 4 (L-4) Depth 2.50 Mtr				
1	OMC	As Per IS : 2720 Part - 08	14.11	%
2	MDD		1.782	gm/cc
3	C.B. R. Value	As Per IS : 2720 Part - 16	4.87	%



GENERAL RECOMMENDATION REGARDING FOUNDATION

- 1) As It is Clear from the boring, that the strata which are met are as follows
 - i) B.C. Soil (ii) Yellow Soil (iii) Boulder (iv) Fractured Rock (v) Moorum (vi) Sandy Material

These strata are consistent in nature and show variation along various bores.

- 2) In BH - 1, 2, 3, 10 i.e. at location L4, L3, L2 & L1 respectively there is filled up material topped by a bituminous layer upto 0.70 mtr from GL, Followed by a layer of B.C. Soil 2.0 Mtr Thick (Approximately) While in BH - 4, 5, 6, 7, 8, 9, 10, 11 i.e. at location L5, L7, L11, L10, L9, L6, L1, L8 respectively, there is a layer of BC Soil varying in thickness from 1.10 Mtr to 2.10 Mtr.
- 3) The Layer of BC Soil is Followed by a layer of Yellow Soil Varying in thickness from 0.30 Mtr to 3.00 Mtr.
- 4) The Layer of Yellow Soil is followed by a layer of boulder at location L3, L4, L5 which varies in thickness from 1.50 Mtr. To 3.00 Mtr.
- 5) Moorum is found at location L6, L9, L10, L11 varying in thickness from 1.50 Mtr. To 4.90 Mtr.

- 6) Based on the above discussion, it may be recommended as follows

- Any foundation shall be avoided on B.C. Soil as it is highly plastic in nature. This Type of Soil tends to show expansive nature and hence it is preferable to remove this soil from locations which have important structures/Pavement and Replace with good soil having No or Very Little Swelling/Shrinkage Properties (Within Permissible Limits)

Further if Removal of this Layer is not feasible, the soil can be stabilized using suitable measures, hence improving the overall nature of the soil

- 6.2) The Layer of Yellow Soil, Moorum, Boulder may be used to lay any foundation at a Shallow Depth.

- 6.3) The Recommended SBC may be Summarized as Below Taking various Sizes of Footing at Shallow Depths

Sr. No.	Location	Depth in Mtr	Footing Size	Recommended of SBC in T/M ²
1	L4	2.80	3 x 3	14.00
2	L3	2.80	3 x 3	14.00
3	L2	2.80	3 x 3	14.00
4	L5	2.50	3 x 3	15.00
5	L7	2.50	3 x 3	14.00
6	L11	2.50	3 x 3	14.00
7	L10	2.50	3 x 3	15.00
8	L9	2.60	3 x 3	16.00
9	L6	2.50	3 x 3	16.00
10	L1	2.80	3 x 3	14.50
11	L8	2.80	3 x 3	15.00
			3 x 3	16.00

- 6.4) Further, the footings shall be isolated column footings with SBC values as mentioned above.

- 6.5) If SBC has to Cause some design concerns, combined footings or raft foundation may also be taken as an alternative





NOTES

1. ALL DIMENSIONS ARE IN MM.
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No.	PRINTS ISSUED TO	DATE
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LEGEND

	EXISTING LAND
	ADDITIONAL LAND REQUIRED = 241 ACRES

No.	REVISIONS	DATE
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UJJAIN

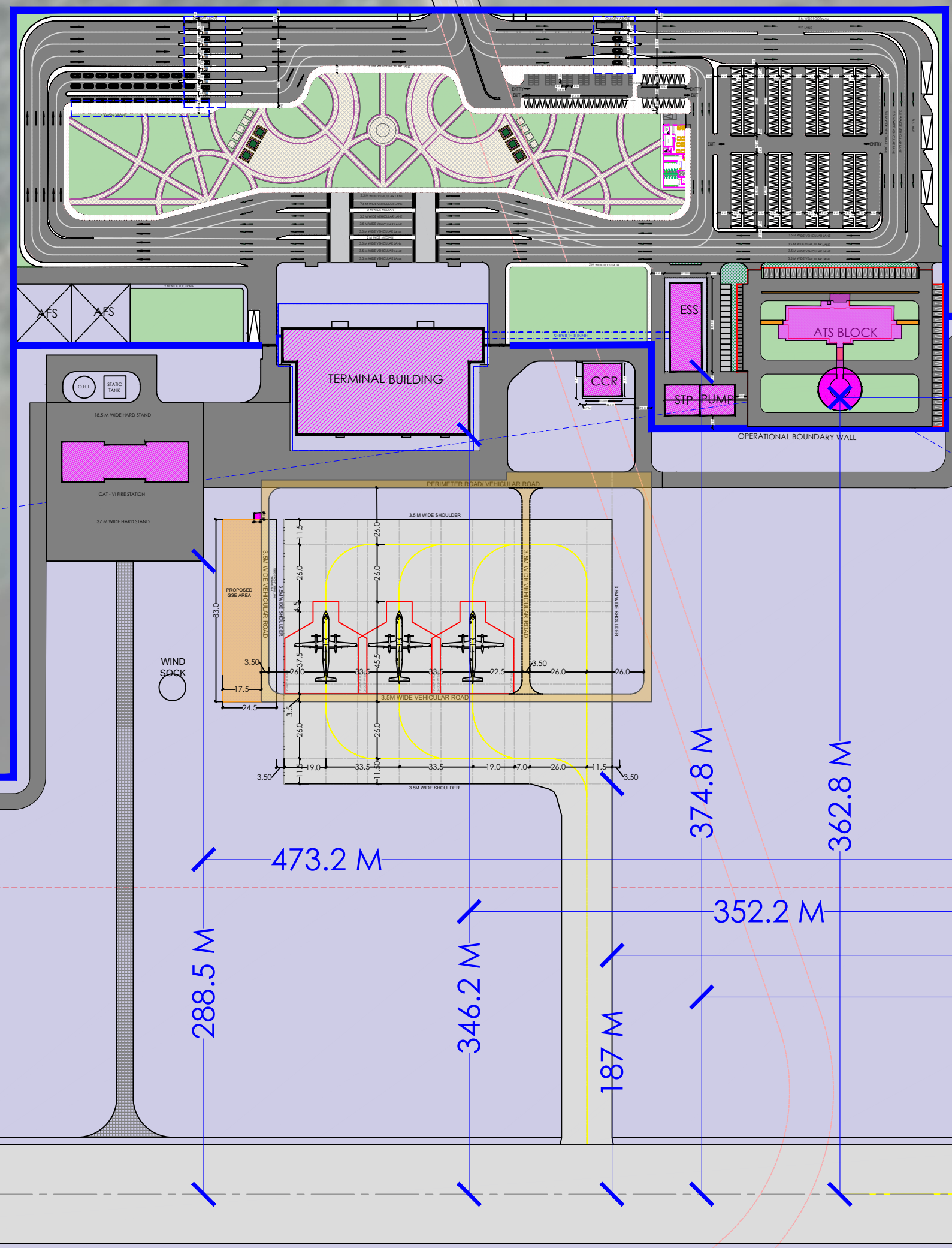
PROJECT TITLE
DEVELOPMENT OF UJJAIN AIRPORT

DRAWING TITLE
MASTER PLAN

AIRPORTS AUTHORITY OF INDIA
DEPARTMENT OF PLANNING
ARCHITECTURAL CELL
RAJIV GANDHI BHAWAN "C" WING SAFDARJUNG AIRPORT, N. DELHI-03

JR. EXE. (ARCH.) KARTIKEYA SRIVASTAVA	JR. EXE. (ARCH.) YATISH NAMAN ASTHANA
MGR. (ARCH.) ANUP BHARTI	SR. MGR. (ARCH.) DHRUBAJYOTI SARDAR
DGM. (ARCH.) MOHSIN KAMAL	DGM. (ARCH.) KANIKA MALIK
G.M. (ARCH.) ANURAG MISHRA	
E.D. (ARCH.) SUJOY DEY	

SCALE	DATE FEBRUARY 2026
DRG.NO. UJJ-AS-001 R	
JOB NO.	



NOTES

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No.	PRINTS ISSUED TO	DATE
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No.	REVISIONS	DATE
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UJJAIN

PROJECT TITLE
DEVELOPMENT OF UJJAIN AIRPORT

DRAWING TITLE

LOCATION PLAN



AIRPORTS AUTHORITY OF INDIA
DEPARTMENT OF PLANNING
ARCHITECTURAL CELL

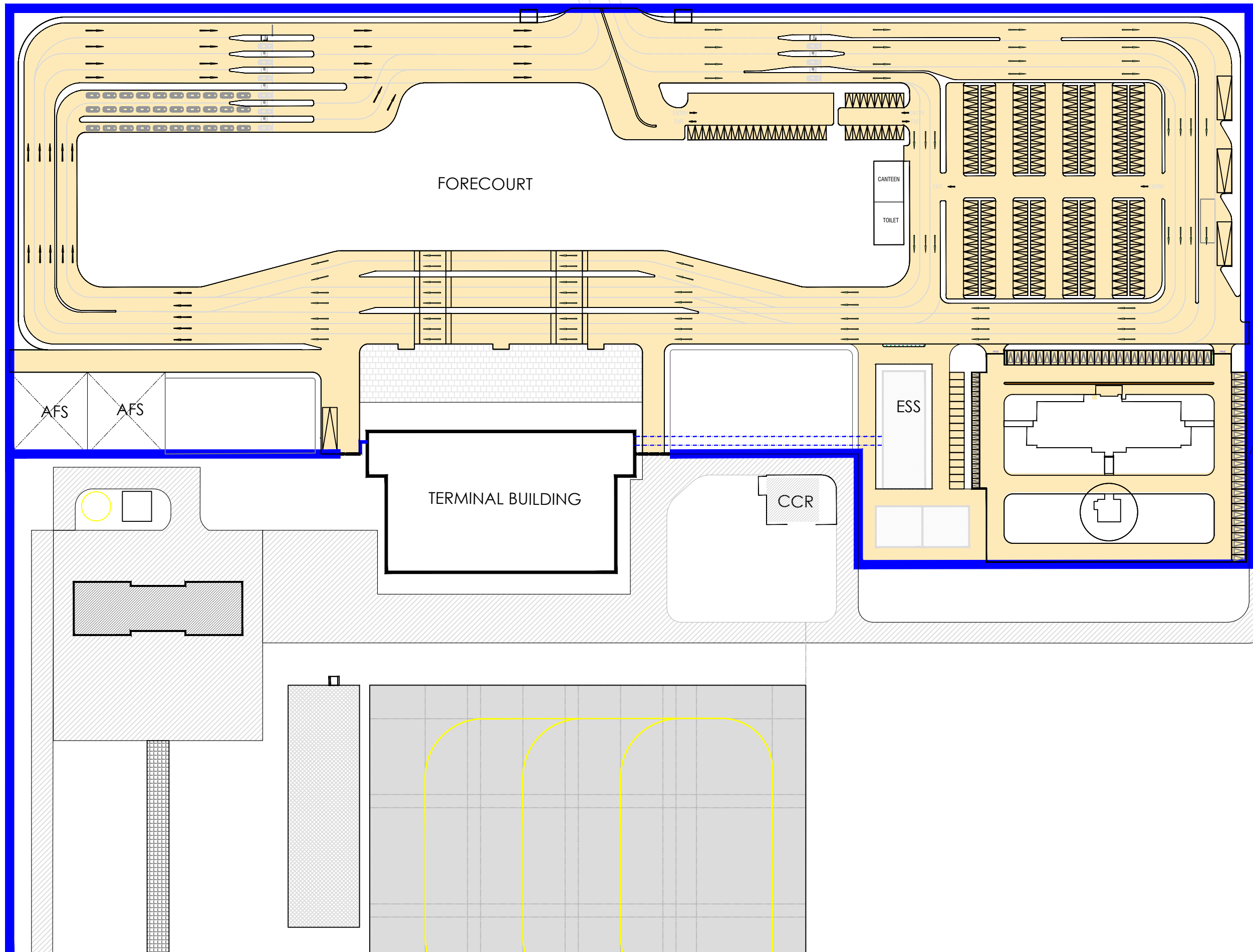
	JR. EXE. (ARCH.) KARTIKEYA SRIVASTAVA	JR. EXE. (ARCH.) YATISH NAMAN ASTHANA
	MGR. (ARCH.) ANUP BHARTI	SR. MGR. (ARCH.) DHRUBAJYOTI SARDAR
	DGM (ARCH.) MOHSIN KAMAL	DGM (ARCH.) KANIKA MALIK

	G.M. (ARCH.) ANURAG MISHRA
	E.D. (ARCH.) SILJOY DEY

SCALE	DATE
	FEBRUARY 2026

FEBRUARY 2020													
DRG.NO.	U	J	J	-	M	P	-	1	0	1	R		

JOB NO.



NOTES

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No.	PRINTS ISSUED TO	DATE
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PAVEMENT AREA = 39,200 SQM (approx.)

No.	REVISIONS	DATE
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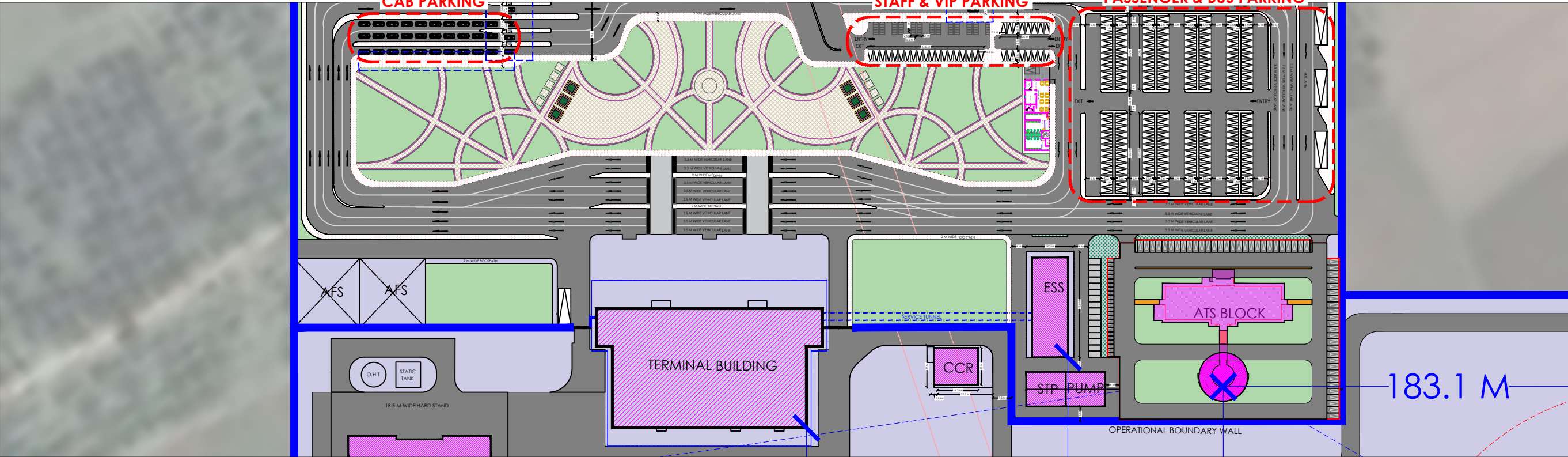
UJJAIN

PROJECT TITLE
DEVELOPMENT OF UJJAIN AIRPORT

DRAWING TITLE
CITY SIDE ROAD LAYOUT

 AIRPORTS AUTHORITY OF INDIA DEPARTMENT OF PLANNING ARCHITECTURAL CELL	AIRPORTS AUTHORITY OF INDIA DEPARTMENT OF PLANNING ARCHITECTURAL CELL RAJIV GANDHI BHAWAN "C" WING SAFDARJUNG AIRPORT, N. DELHI-03										
	JR. EXE. (ARCH.) KARTIKEYA SRIVASTAVA					JR. EXE. (ARCH.) YATISH NAMAN ASTHANA					
	MGR. (ARCH.) ANUP BHARTI					SR. MGR. (ARCH.) DHRUBAJYOTI SARDAR					
	DGM (ARCH.) MOHSIN KAMAL					DGM (ARCH.) KANIKA MALIK					
	G.M. (ARCH.) ANURAG MISHRA										
	E.D. (ARCH.) SUJOY DEY										
SCALE						DATE					
						FEBRUARY 2026					
DRG.NO. UJJ-MP-						102		R			
JOB NO.											

KEY PLAN



NOTES

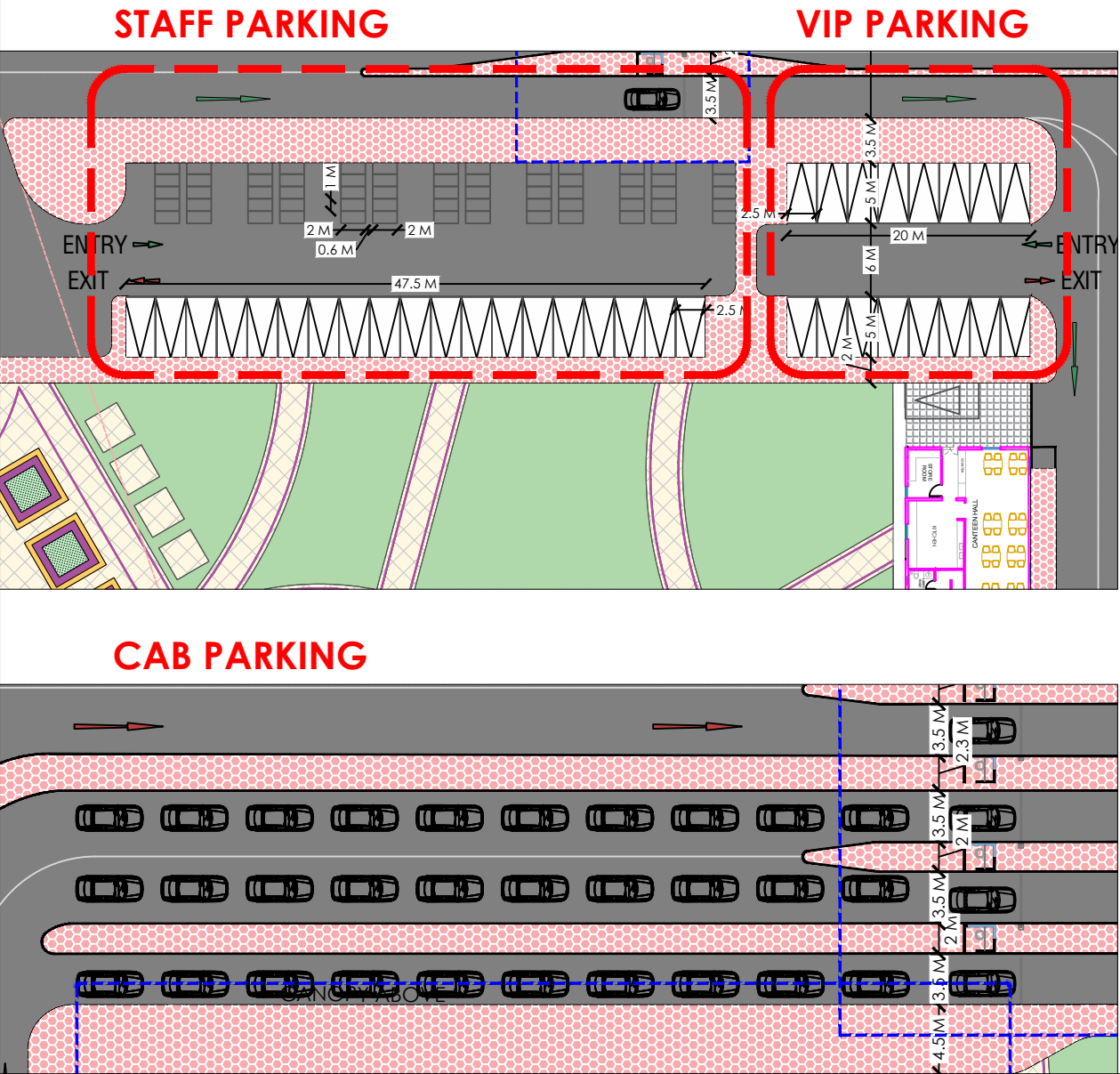
1. ALL DIMENSIONS ARE IN MM.
2. DRAWINGS NOT TO BE SCALED, ONLY WRITTEN DIMENSIONS ARE TO BE FOLLOWED.
3. DISCREPANCY IF ANY, SHOULD BE BROUGHT TO THE NOTICE OF DEPT. OF PLANNING.

No. PRINTS ISSUED TO DATE

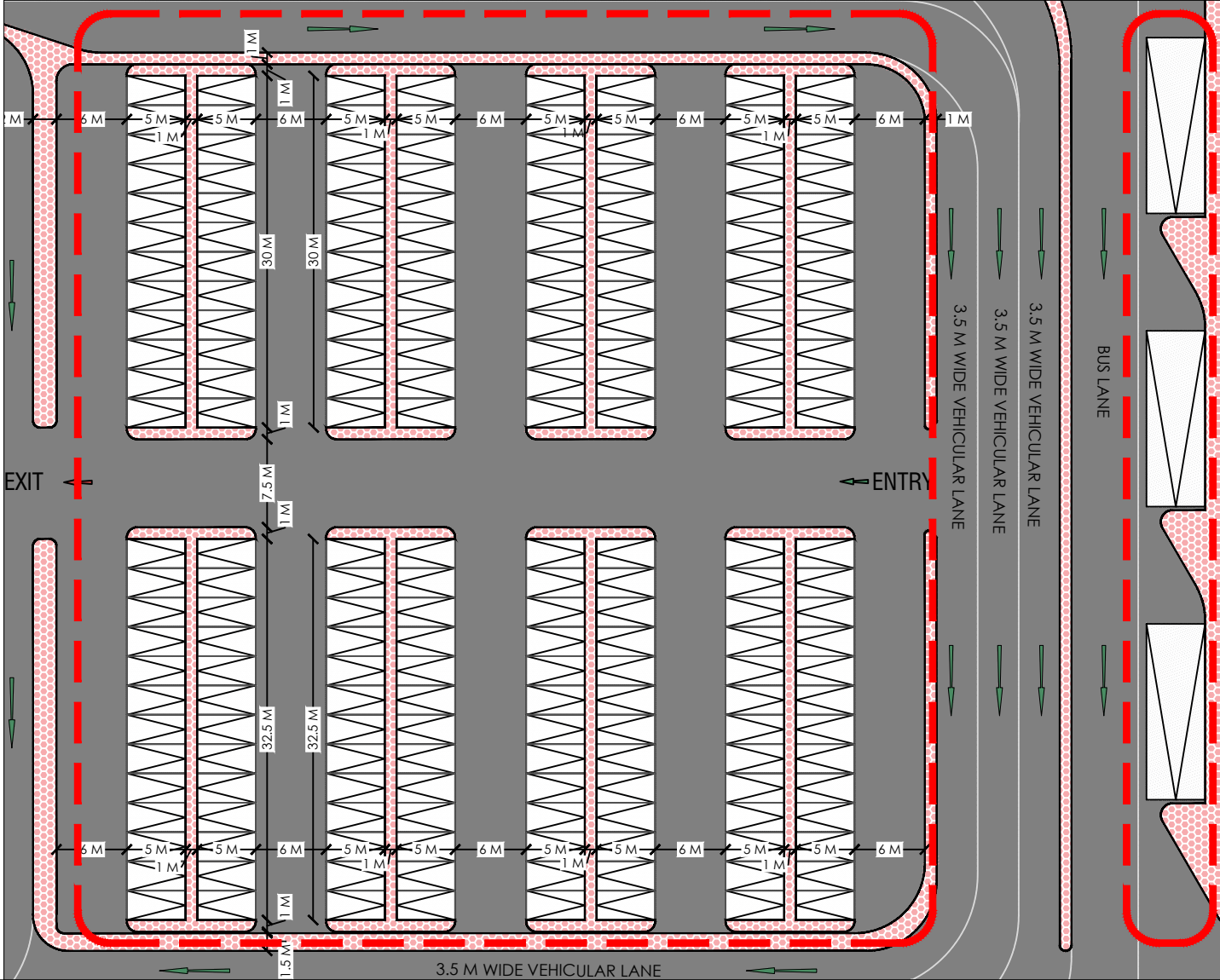
PARKING COUNT

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- * VIP PARKING: 16
- * CAB PARKING: 30
- * BUS PARKING: 03
- * STAFF PARKING: 2-WHEELER PARKING: 65
- 4-WHEELER PARKING: 19

CITYSIDE PARKING LAYOUT



PASSENGER PARKING




No. REVISIONS DATE

UJJAIN

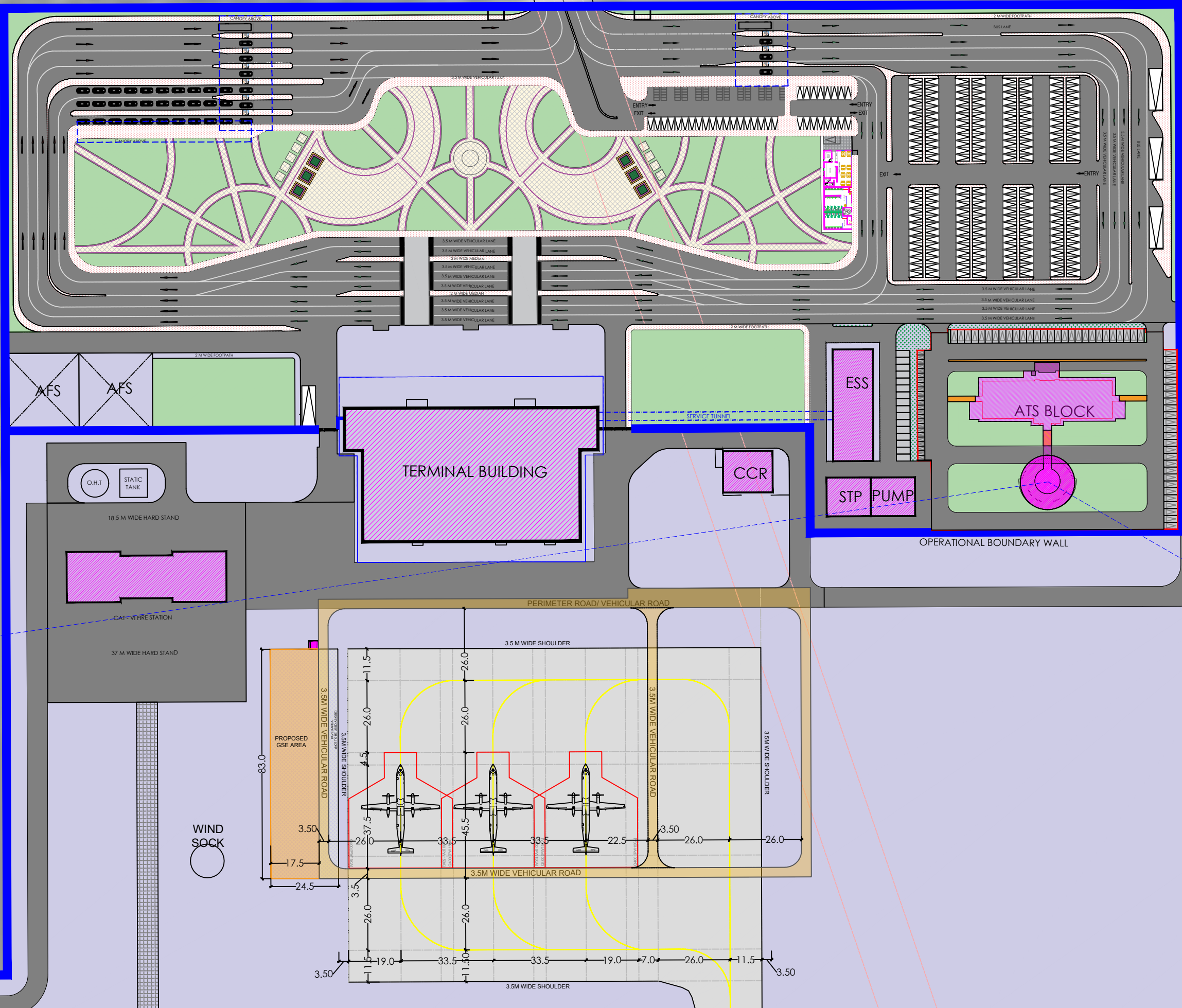
PROJECT TITLE
DEVELOPMENT OF UJJAIN AIRPORT

DRAWING TITLE
CITYSIDE PARKING LAYOUT

 AIRPORTS AUTHORITY OF INDIA DEPARTMENT OF PLANNING ARCHITECTURAL CELL RAJIV GANDHI BHAWAN "C" WING SAFDARJUNG AIRPORT, N. DELHI-03	
JR. EXE. (ARCH.) KARTIKEYA SRIVASTAVA	JR. EXE. (ARCH.) YATISH NAMAN ASTHANA
MGR. (ARCH.) ANUP BHARTI	SR. MGR. (ARCH.) DHURUBAJYOTI SARDAR
DGM. (ARCH.) MOHSIN KAMAL	DGM. (ARCH.) KANIKKA MALIK
G.M. (ARCH.) ANURAG MISHRA	
E.D. (ARCH.) SUJOY DEY	

SCALE
DRG.NO. UJJ-MP-103 R
JOB NO.

DATE
FEBRUARY 2024



NOTES

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No. PRINTS ISSUED TO DATE

No. REVISIONS DATE

UJJAIN

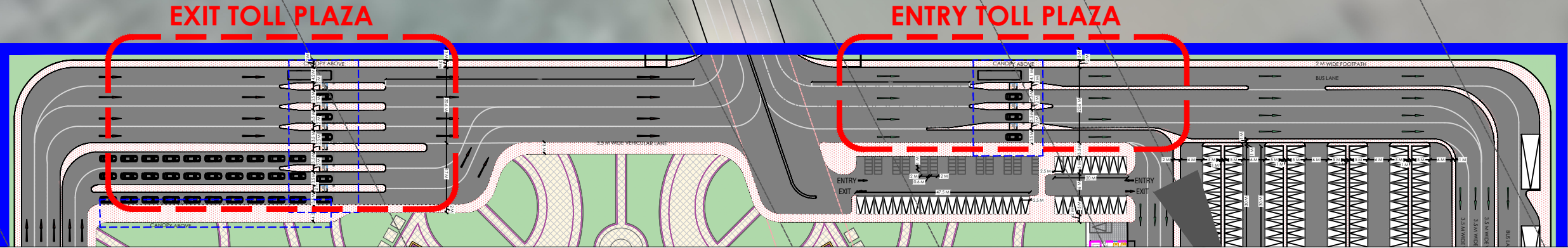
PROJECT TITLE
DRAFT MASTER PLAN

DRAWING TITLE
SITE LAYOUT PLAN

 AIRPORTS AUTHORITY OF INDIA DEPARTMENT OF PLANNING ARCHITECTURAL CELL RAJIV GANDHI BHAWAN 'C' WING SAFDARJUNG AIRPORT, N. DELHI-03	
JR. EXE. (ARCH.) KARTIKEYA SRIVASTAVA	JR. EXE. (ARCH.) YATISH NAMAN ASTHANA
MGR. (ARCH.) ANUP BHARTI	SR. MGR. (ARCH.) DHIRUBAJYOTI SARDAR
DGM (ARCH.) MOHSIN KAMAL	DGM (ARCH.) KANIKA MALIK
G.M. (ARCH.) ANURAG MISHRA	
E.D. (ARCH.) SUJOY DEY	

SCALE
DRG.NO. UJJ-MP-105 R
JOB NO.
DATE
FEBRUARY 2026

KEY PLAN

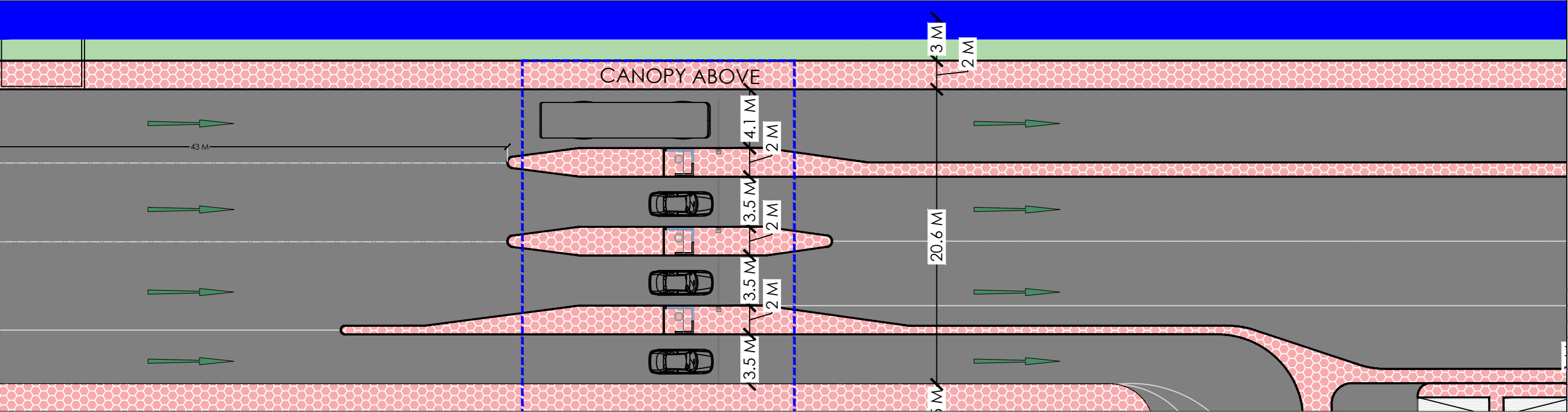


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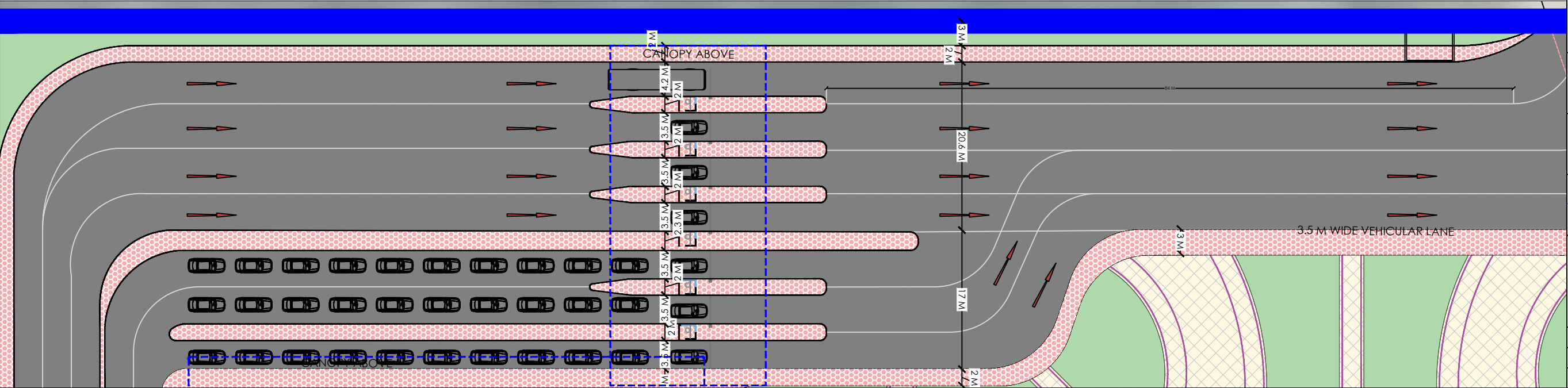
- 1. ALL DIMENSIONS ARE IN MM.
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ENTRY TOLL PLAZA



EXIT TOLL PLAZA



No.	REVISIONS	DATE
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UJJAIN

PROJECT TITLE
DEVELOPMENT OF UJJAIN AIRPORT

DRAWING TITLE
TOLL PLAZA LAYOUT

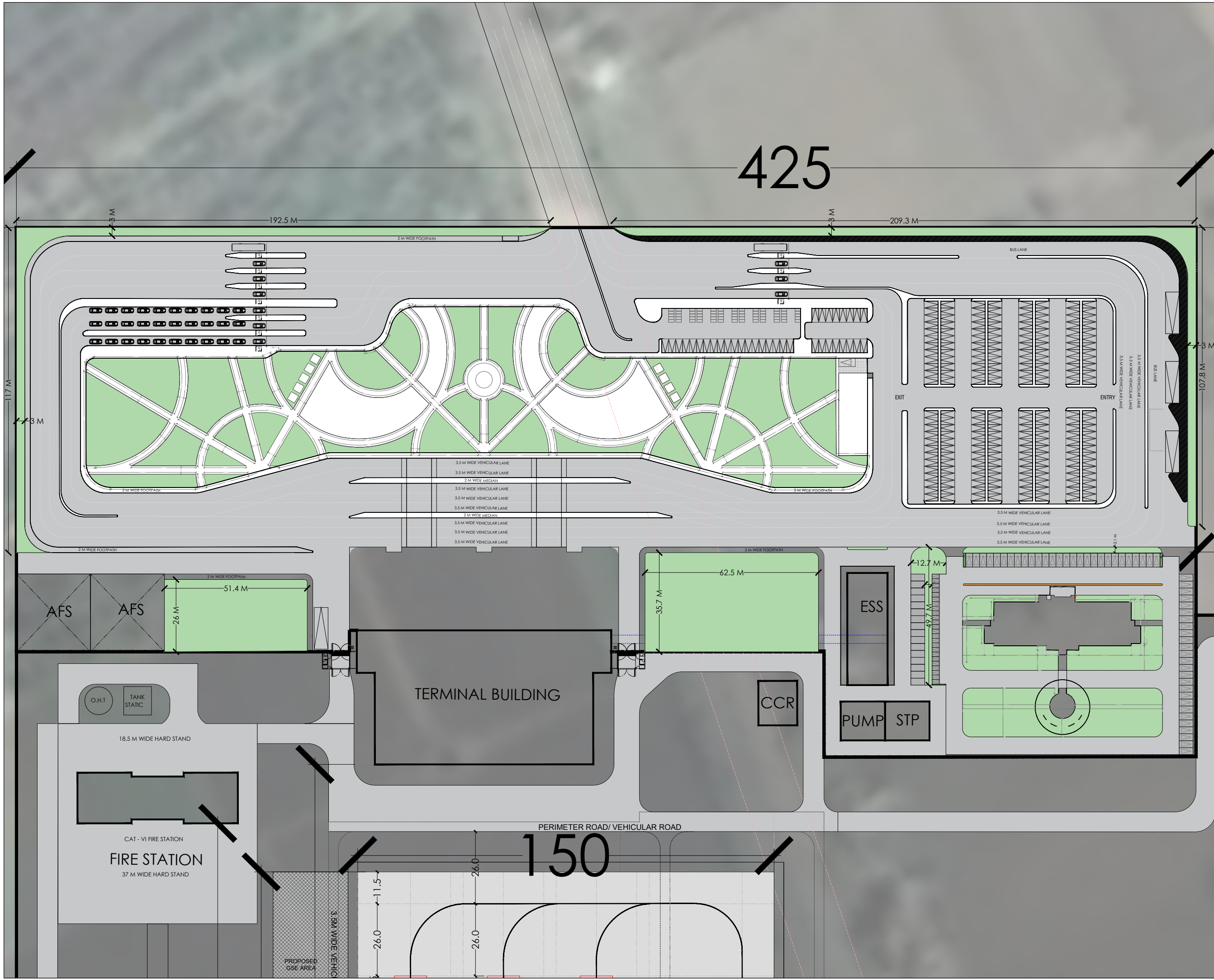
AIRPORTS AUTHORITY OF INDIA
DEPARTMENT OF PLANNING
ARCHITECTURAL CELL

RAJIV GANDHI BHAWAN "C" WING SAFDARJUNG AIRPORT, N. DELHI-03

JR. EXE. (ARCH.) KARTIKEYA SRIVASTAVA	JR. EXE. (ARCH.) YATISH NAMAN ASTHANA
MGR. (ARCH.) ANUP BHARTI	SR. MGR. (ARCH.) DHRUBAJYOTI SARDAR
DGM. (ARCH.) MOHSIN KAMAL	DGM. (ARCH.) KANIKKA MALIK
G.M. (ARCH.) ANURAG MISHRA	
E.D. (ARCH.) SUJOY DEY	

SCALE
DRG.NO. U J J - M P - 1 0 6 R
JOB NO.

DATE
FEBRUARY 2026



NOTES

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No.	PRINTS ISSUED TO	DATE
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LEGENDS:

AREA TO BE LANDSCAPED

NOTE:

LANDSCAPE AREA = 14,500 SQM (APPROX.)
LANDSCAPE CONSULTANT MAY CONSIDER DRIP IRRIGATION FOR THE LANDSCAPE AREA

No.	REVISIONS	DATE
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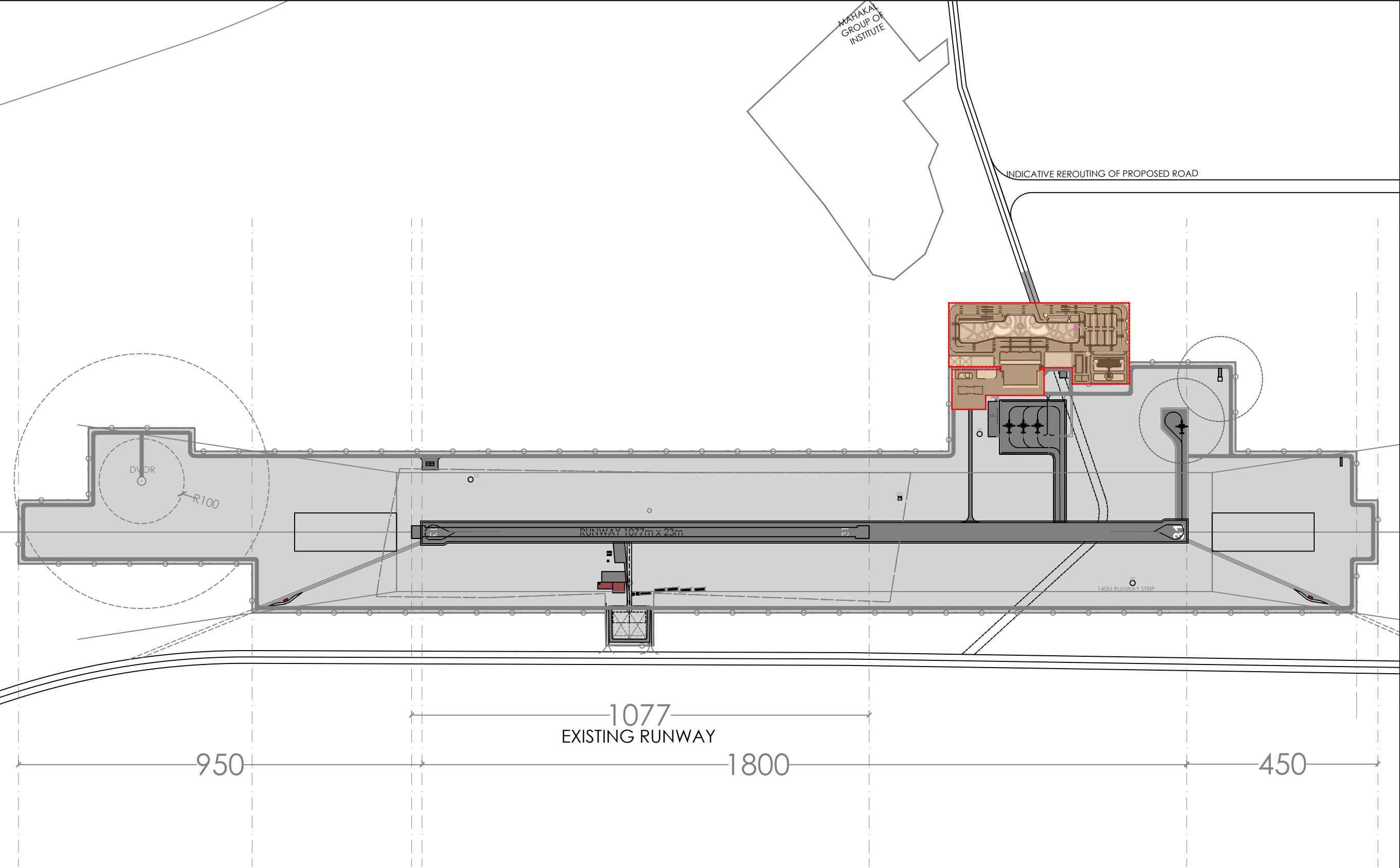
UJJAIN

PROJECT TITLE
DEVELOPMENT OF UJJAIN AIRPORT

DRAWING TITLE
VEGETATION PLAN

 AIRPORTS AUTHORITY OF INDIA DEPARTMENT OF PLANNING ARCHITECTURAL CELL RAJIV GANDHI BHAWAN "C" WING SAFDARJUNG AIRPORT, N. DELHI-03	
JR. EXE. (ARCH.) KARTIKEYA SRIVASTAVA	JR. EXE. (ARCH.) YATISH NAMAN ASTHANA
MGR. (ARCH.) ANUP BHARTI	SR. MGR. (ARCH.) DHRUBAJYOTI SARDAR
DGM (ARCH.) MOHSIN KAMAL	DGM (ARCH.) KANKA MALIK
G.M. (ARCH.) ANURAG MISHRA	
E.D. (ARCH.) SUJOY DEY	

SCALE	DATE FEBRUARY 2026
DRG.NO. U J J - M P - 1 0 7 R	
JOB NO.	



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LEGENDS

BATTERY LIMIT

NOTE:


- Refer this drawing only for Battery limit of City Side Package.
- For Details of City Side infrastructure, kindly refer the other detail drawings (Relevant drawings). This drawing is symbolic and schematic only.

No.	REVISIONS	DATE
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UJJAIN

PROJECT TITLE
DEVELOPMENT OF UJJAIN AIRPORT

DRAWING TITLE
BATTERY LIMIT - CITY SIDE PACKAGE

 AIRPORTS AUTHORITY OF INDIA DEPARTMENT OF PLANNING ARCHITECTURAL CELL <small>RAJIV GANDHI BHAWAN "C" WING SAFDARJUNG AIRPORT, N. DELHI-03</small>	
JR. EXE. (ARCH.) KARTIKEYA SRIVASTAVA	JR. EXE. (ARCH.) YATISH NAMAN ASTHANA
MGR. (ARCH.) ANUP BHARTI	SR. MGR. (ARCH.) DHRUBAJYOTI SARDAR
DGM (ARCH.) MOHSIN KAMAL	DGM (ARCH.) KANIKA MALIK
G.M. (ARCH.) ANURAG MISHRA	
E.D. (ARCH.) SUJOY DEY	
SCALE	DATE JANUARY 2026
DRG.NO. UJJ - MP - 108 R	
JOB NO.	