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Bharat Heavy Electricals Ltd.  
Doc. No. TB-383-607-003 R-1

**TECHNICAL SPECIFICATION FOR CIVIL WORKS OF 66 KV GIS AT ONGC HAZIRA  
CCCP (1X51MW)**

# **SECTION-1**

**SCOPE, SPECIFIC TECHNICAL REQUIREMENTS &  
QUANTITIES**

## **SECTION - 1**

### **SCOPE, SPECIFIC TECHNICAL REQUIREMENTS & QUANTITIES**

#### **.1.0 SCOPE**

1.1.1 The scope of work under this specification is Civil Works of **66 KV GIS AT ONGC HAZIRA CCCP (1X51MW)** being executed by BHEL on turnkey basis. The Customer is **OIL AND NATURAL GAS CORPORATION LIMITED** & their consultant **FICHTNER Consulting Engineers (India) Private Limited**, Bangalore.

1.1.2 The Civil Works shall generally include, *but not limited to*, following:

- (i) GIS Building Works.
- (ii) Tower and Equipment foundations.
- (iii) Cable trenches including precast covers & cable trench crossings.
- (iv) Road and Drainage.
- (v) Fencing & Gate
- (vi) Gravel spreading
- (vii) Dismantling
- (viii) Any other work required for the project.

1.1.3 The works to be performed in the above construction includes preparation of bar bending schedules, based on the drawings released for construction and getting the same approved by the Engineer-in-charge plus the execution of the work including providing of all labour, supervision, materials, scaffolding, power, fuel, construction equipments, tools and plants, supplies, transportation, all incidental items necessary for successful completion of the work including contractor's supervision and in strict accordance with the drawings and specifications and with inspection and testing standards. The nature of work shall generally involve excavation in all type of soil including dewatering, shoring, strutting, and filling under and around structures, backfilling with available excavated earth around completed structures, cable trenches with covers, disposal of surplus soil, steel/wooden ply formwork, providing necessary steel embedment and other inserts, drainage work, concreting, brickwork, flooring and finishing etc. and all other works in building all complete as per detailed specification, drawings and directions of Engineer-in-charge.

#### **1.2.0 SPECIFIC TECHNICAL REQUIREMENT**

1.2.1 The specific technical requirements for the execution of civil works shall be as per Customer's specification (Doc no. 511168-ME-SPC-100-001) / I.S. Codes/ Specification. In case of any conflict between these, Customer's specification shall prevail.

#### **1.3.0 BILL OF QUANTITIES**

1.3.1 The Bill of Quantity cum price schedule shall be as per page **1.3 to page 1.13**.

- 1.3.2 The quantities indicated in the 'Bill of Quantity cum price schedule' are indicative and can vary upto any extent, even may get deleted. Contractor shall not be entitled for any claim for any such variation in the quantities.
- 1.3.3 The provision of Bill of Quantity cum price schedule, specifications and drawings shall be read in conjunction with each other and in case of conflict amongst them, the clarification shall be obtained from the Engineer-in-charge whose decision shall be final and binding.
- 1.3.4 Method of measurement:
- 1.3.4.1 Excavation shall be measured in cubic meters. The lateral dimensions to be considered for working out excavation quantity shall be the PCC dimension below the footing as per approved drawing. Nothing extra shall be paid for slope cutting, etc. Backfilling & disposal quantities shall be worked out based on the above dimensions only. However the contractor shall maintain the required slope and working space as per the safety /statutory requirement and its cost is deemed to be included in the quoted rate.

For other items, unless otherwise described the method of measurement as described in 'Method of Measurement of Building and Civil Engineering Works'-IS 1200(Part I to XXV) latest edition of BIS shall be followed

Bharat Heavy Electricals Ltd.

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**TECHNICAL SPECIFICATION FOR CIVIL WORKS OF 66 KV GIS AT ONGC HAZIRA  
CCCP (1X51MW)**

# **SECTION-2**

**STANDARD TECHNICAL SPECIFICATION**

**(NA )**

Bharat Heavy Electricals Ltd.

Doc. No. TB-383-607-003 R-1

**TECHNICAL SPECIFICATION FOR CIVIL WORKS OF 66 KV GIS AT ONGC HAZIRA  
CCPP (1X51MW)**

# **SECTION-3**

**ENCLOSURE TO TECHNICAL SPECIFICATION  
- CUSTOMER TECHNICAL SPECIFICATION**



# OIL AND NATURAL GAS CORPORATION LIMITED

## GAS BASED COMBINED CYCLE CAPTIVE POWER PLANT

**COGENERATION & STEAM SYSTEM  
AT HAZIRA PLANT, SURAT – 394 518  
GUJARAT**



## **BID PACKAGE FOR COMBINED CYCLE CAPTIVE POWER PLANT**

Consultant : **FICHTNER Consulting Engineers (India) Pvt. Ltd.**  
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International Infotech Park,  
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PROJECT :

**COMBINED CYCLE CAPTIVE POWER PLANT  
AT HAZIRA PLANT, GUJARAT**

TITLE :

**BID PACKAGE FOR  
COMBINED CYCLE CAPTIVE POWER PLANT  
AT HAZIRA PLANT, GUJARAT**

CLIENT :



**OIL AND NATURAL GAS CORPORATION LIMITED**

DOC. NO. :

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R0	17.05.2012	PGT	Sd/-	SKS	Sd/-	SG	Sd/-	SG	Sd/-	For Tender purpose only
REV.	DATE	INITIAL	SIGN	INITIAL	SIGN	INITIAL	SIGN	INITIAL	SIGN	DESCRIPTION
		PPD. BY		CHKD. BY		APPD. BY		CLEARED BY		

Consultant : **FICHTNER Consulting Engineers (India) Pvt. Limited, Navi Mumbai.**

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BID PACKAGE  
FOR  
COMBINED CYCLE CAPTIVE POWER PLANT  
AT HAZIRA PLANT, GUJARAT


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# TECHNICAL SPECIFICATION

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- Corrosion protection for underground/ over ground RCC and steel structures
- Crane way works
- Service water and waste water, sewage water, storm water (permanent and during construction).
- Housekeeping during construction (at least once a week total)
- Staff facilities during construction
- Transport of all dumping material to dump locations (at least once a week ).
- Proper drainage arrangement has to be ensured, so that adjacent plant area should not get affected.

**4.0.0 PROVISIONS BY THE OWNER/OWNER'S REPRESENTATIVE**

Refer Volume-I (Commercial Specification)


**5.0.0 SITE CONDITION**

**5.1.0 Meteorological Conditions and other Project information**

**ONGC, Hazira Site conditions:**

1.0	Location	ONGC Limited, Hazira
2.0	Elevation above mean sea level	RL 6.0 above, MSL
3.0	Nearest Railway Station	Surat, 20 KM
4.0	Nearest Airport	Surat, 10 KM
5.0	Nearest Harbour	Magdalla, 20 KM
6.0	Access Road	NH-8 (30 KM)
7.0	Atmospheric pressure at MSL	1.013 bar
8.0	Ambient Temperature	
a)	Max. average dry bulb temperature	45.6 °C
b)	Min. average dry bulb temperature	4.4 °C
c)	Design temperature for electrical equipment / device	50 °C
9.0	Relative Humidity	
a)	Max.	70%
b)	Min.	18%
c)	Average	64%
10.0	Seismic Zone	III (IS 1893)
11.0	Rainfall	
a)	Max. intensity of rainfall in 24 hrs.	459.2 mm
b)	Period – Monsoon showers	June to September
c)	Average rainfall per annum	1203.5 mm
12.0	Wind data	
	Max. wind speed (as per IS:875) 20-61 kmph for 20 days in a year < 20 kmph for remaining period	62 kmph
	Most predominant wind direction	South - West
13.0	Land	
14.0	Tropicalisation	
	All equipment supplied against specification shall be given tropical and fungicidal treatment in view of the climatic conditions prevailing at site.	
	Tropical protection shall conform to BS: CP-1014-1965 "Protection of Electrical Power Equipment" against climatic conditions.	

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15.0	Electrical	
	Refer Volume-III, Section-3, Detailed Technical Specification – Electrical of this tender document.	

**5.2.0 Design requirements related to site conditions**

The Plot Plan is shown in the enclosed Drawing No. 10-5111168-G-001, ( Rev C).

However Contractor shall optimise the layout based on configuration and his standard equipment layout.

**6.0.0 PLANT LAYOUT AND SITE PREPARATION WORKS**

**6.1.0 Plant Site**

**6.1.1 Site Plot Plan**

In developing the site layout, a system approach shall be adopted with a view to ensure that all the subsystems comprising the power plant are optimally laid out both from the view point of capital cost as well as running costs.

Plot Plan is enclosed as Drg. No: 10-5111168-G-001, (Rev C). However, the Contractor shall further develop layout and arrangement which shall be subject to approval of the Owner/Owner's representative.

The development work consists primarily of clearing the site, grading the site to appropriate levels keeping in view the planning for storm water drainage and green belt and barricading the proposed power plant from operation plant for the construction facility needs.

**6.1.2 Earthworks and Site Grading**

Earthwork in excavation including rock quarrying/blasting if required, identifying borrow pits, transportation of soil from borrow pits, backfilling, disposal of excavated soil is required.

Site is generally plain but necessary grading/levelling required for the construction shall be done by the Contractor. The area shall be suitably cut and filled to suit the layout requirement if required.


Additional soil for levelling for site grading shall be obtained.

**6.1.3 Roads, Fencing and Compound Wall**

Approach roads to the plant site shall be provided to access from existing road network. Roads as required for plant operation & maintenance inside the proposed plant boundary shall be provided. The layout concept of roads is shown in Plot plan. The main plant existing roads area of double lane and the peripheral roads along the proposed power plant shall be of single lane.

66kV GIS, Transformer area, Gas Conditioning and similar unsafe areas shall be fenced off using PVC sheathed GI chain link fencing supported on precast post.

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**6.2.0 Layout of power plant area**

**6.2.1 General**

The following factors shall be considered in developing the plant layout.


- a) The layout of this Station shall be compact so as to optimize use of land, materials and minimize system losses.
- b) Adequate provision shall be made in regard to space and access in order to carry out the maintenance of equipment. Adequate maintenance facilities shall be provided as required, for assembly, disassembly and handling during maintenance of equipment.
- c) Due consideration shall be given for the wind direction while deciding on the relative location of Cooling tower and 66kV GIS to minimize the moisture drift towards the GIS.
- d) Adequate space shall be provided for unloading and maintenance purposes in Turbine - Generator (TG) area. Requisite lay down area shall be provided for proposed unit on TG floor GTG area and same shall be approachable with electric overhead travelling (EOT) crane.
- e) Adequate fire escape staircases shall be provided in power house building with fire doors at each landing.
- f) EPC Contractor shall provide the following:
  - 1. For HRSG one emergency exit through chimney staircase in addition to normal staircase.
  - 2. Two staircases for Switchgear room/control room 66 KV Indoor Gas insulated sub-station
  - 3. Two exits for Central Control Room, the elevation (at 2.5 m above the FGL)
  - 4. Cooling tower will have two staircases.
- g) The safety requirements as per the Factories Act, Indian Electricity Rules and other applicable codes/standards shall be observed while developing the layout.
- h) Adequate maintenance facilities shall be provided as required, for assembly, disassembly, handling during maintenance and alignment work of all important equipments and auxiliaries viz., Gas Turbine, steam turbine casing (inner and outer), diaphragm glands, steam valves, journal/thrust bearings, turbine rotors, generator rotor, end rings, shaft seals, generator bearings, condenser water box, vacuum pumps, CEPs and BFP parts, BFP drive motor, turbine oil coolers, pumps.

**6.2.2 Power Block Area**

The following building / structures and equipment shall be located within power Block.

- Gas Turbine Generator, Steam Turbine and Generator Hall
- HRSG area
- Deaerator and Boiler Feed water pump area
- Control and switchgear building
- Power Cycle pipe rack and cable gallery
- Transformer yard area

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A suggested General Arrangement concept of Power Blocks is shown in Plot plan. Bidder shall develop an optimized Layout of the Power Blocks to suit the configuration and equipment offered.

Clear walk ways of minimum 1.5 m width at all the levels shall be provided in the main plant building. TG fire escape staircases shall be provided in main plant building with fire doors at each landing.

For EOT crane maintenance, through walkway shall be provided along both rails at crane girder level. Approach to the crane through rung ladders shall be provided at least at two places.

Gas turbine, Steam turbine, generator, Lube oil system, CEP, and other equipments located in the turbine hall shall be accessible by the EOT cranes for their handling during maintenance and overhauling. For all other equipment/ components located in the main plant building, suitable handling arrangement viz. cranes/ chain pulley blocks/monorail hoists as required shall be provided for the maintenance and overhauling. Wherever special handling procedures are to be followed, the same shall be described in a separate document.

Floor drains shall be provided at all floors and drain discharge pipes shall be properly sized taking into account the fire water sprinkler system wherever provided.

**Gas Turbine, Steam Turbine and Generator (TG) Hall.**

The GTG shall be accommodated in a common Gas Turbine and Steam Turbine Hall of adequate span based on the model and frame size.

GTG/STG building shall be of steel framed building . Adequate space for maintenance of Steam Turbine, Gas Turbine and Generator shall be provided in the layout. The Gas Turbine, Steam Turbine and Generator lay down area shall be provided. Rolling shutter(s) / extended platform shall be provided to facilitate withdrawal of Generator rotor.

EOT crane shall be provided for TG hall for maintenance of equipment / components.

The off base equipment of Gas Turbines shall be located adjacent to the main Gas Turbine on skids ensuring EOT Crane access for the same wherever it is necessary.

**HRSG area**


The HRSGs associated with GTGs shall be located on the side of Gas Turbine building.

Shelter with necessary ventilation shall be provided for BFPs. Shelter shall be also provided with wall cladding as necessary. For SWAS dry section suitable Air Conditioning shall be considered.

The lay down area shall be provided on any one side of HRSG, which would facilitate easy access for erection and maintenance. Electrical drive Equipment located outdoor shall be provided with covered roof /canopy.

In the HRSG area, facility of crane/ chain pulley block/ monorail hoist shall be provided along with provision of space for maintenance/ overhauling of equipment such as boiler circulation pumps, motors, and handling of coils of economizer.

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### Control Room

The control room will be physically divided into sections. Each section will be separated by glass wall and entry door. The system cabinets and all other non-indicating type panels will be housed in one section. Operator consoles, printers, and control desks, auxiliary control panels will be housed in one section. UPS cabinets will be housed in one section. Double door air curtain facilities will be provided at the entry to the control room and the control room will have minimum two entries and exits. Ample space will be provided around the instrument panel / desk, about a minimum of 1.0 m to 1.5 m. The door will be made of glass fixed in aluminium frames. The glass panels will be long preferably one sheet of each frame. The control room will be air-conditioned. The bidder shall do engineering accordingly.

- **Wall panels & windows**

A soundproof glass panel shall be provided for CCR. The walls and panels shall provide good acoustic insulation, shall prevent the ingress of dust and shall ensure the efficient operation of the air-conditioning system within the Central Control Room (CCR).

- **Other equipment**

A sufficient number of chairs shall be provided for the operating personnel. These chairs shall be capable of being adjusted for height and position of backrest. The chairs shall be mounted on five castors, shall swivel and shall have arm rests.

The central control room shall also include sufficient number of file cupboards & printer tables which shall be matching in appearance and dimension with the other hardwares located in the control room.

### Transformer Yard area

All power transformers (GTG/STG/Station) shall be located outdoor.


Generator transformers shall be located near to the generator to reduce the length of the bus duct from the generator. LT transformers shall be located adjacent to switchgear building in the transformer yard. If dry type LT transformers are provided, it shall be located indoor.

Layout of facilities and equipment shall allow removal of generator transformers, station transformers and without disturbing structure, equipment, piping, cabling, bus ducts routed in the area. Suitable rail track and associated facilities like jacking pads, anchor blocks shall be provided to facilitate the movement of generator transformers (GTG/STG), station transformers to the maintenance bay. The Heat generating electrical equipments including the transformers shall not be placed near to the GT inlet Air filter.

### 6.2.3 Balance of Plant Areas

The Balance of plant areas consists mainly of the following:

- a) Water System area
- b) CCW / ACW pump area
- c) Air compressor / workshop area
- d) Waste water forwarding to existing effluent treatment plant.
- e) Cooling tower area
- f) Fuel gas Handling system area
- g) Black start, Emergency DG Area
- h) 66kV Gas Insulated Substation (GIS) area

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The Cooling Towers (CT) and CW/ACW pumps shall be suitably located considering buried (to a large extent) cooling water piping to and from the power blocks, except at condenser and CW pumphouse end, where it will be above ground and the CT make-up water piping from the water makeup pump area. The CW pumps shall be located in the CW pump area at CT weir end and cooling water from the CT will enter the CW sump through a closed forebay. ACW pump will be taking suction from the closed Cooling Water fore bay.

The air compressor shall be housed in a Structural steel building. The building shall have space provision for future air compressor. The compressor house shall have a maintenance bay for the air compressor, In addition, workshop area also to be considered in the compressor house. The workshop shall house a radial drilling machine, pedestal grinder and table with vice.

The interconnection pipework between plant utilities and power block equipment shall be routed through pipe racks / sleepers, pipe trenches or buried. The CCW / ACW water piping shall be laid below ground and buried to the extent feasible. Cathodic protection shall be provided for all buried metallic pipelines (such as CCW system, and discharge system etc,) except for such pipes (such as fire protection system etc) running in RCC trenches. Trestles / Pipe Bridge to be provided for routing of cables, pipes shall have a clear height of 7.5m at road crossings for normal traffic & 11.0 m for crane movement A walkway with hand rails and toe guards of 750 mm (minimum) width shall be provided all along length of the trestle for maintenance of cables and pipes. Ladders for approach to these platforms shall be provided near roads, passage ways.

CO<sub>2</sub> cylinders banks for GT fire protection shall be stored under a sunshade (if outdoor) and not in an enclosure

Valves shall be located in accessible positions. All piping shall be routed at a clear height of minimum 2.2 m from the nearest access level for clear man movement. Best engineering practices shall be adopted for keeping the minimum clear working space around equipment and clear headroom within main structures and cable trays.

Fire water pipes in power block area may be routed in trenches covered with pre-cast RCC covers or buried with coating covered with sand with due consideration of lack of corrosion protection.

**6.2.4 Non-plant Buildings**

Any other non-plant buildings like Administration building, canteen building, O & M building, is not envisaged in Contractor's scope.

**6.3.0 Layout and other facilities**


**6.3.1 DM and CW make-up storage tank**

The DM and CW make-up water storage tank shall be above ground water storage tank with top roof closed .The DM water transfer pumps shall be located adjacent to the DM water storage tank.

**6.4.0 Hazardous areas, fire protection provisions**

**Hazardous areas (Refer Area Classification Plan (Overall) – Drawing No. 3114-00-16-50-0005, Rev.0 & Hazardous Area Classification Diagram (Drg.No. 1-38101-00213, Rev.0) enclosed under List of tender drawings (Vol-IV,Sec-6).**

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The Bidder shall take full account of any special requirements concerning the nature, handling and storage of all oils, gases and chemicals and provide plant, equipment, buildings and other services accordingly, including all facilities to ensure the safety of the operating and maintenance personnel.

Areas where a potential flammable atmosphere may exist shall be classified in accordance with the provisions of latest version of relevant IS. Certified equipment shall be used in the designated hazardous areas. To the extent practicable, equipment requiring operator's attention and/or electrical equipment shall not be installed in hazardous areas.

The Bidder shall provide drawings to define all the hazardous zones taking account of all sources of hazards under normal and abnormal operating conditions, (regardless of whether or not these areas are specifically listed in the specification). The zoning philosophy shall be subject to the approval of the Owner/Owner's representative and shall follow OISD standards.

In particular, equipment directly concerned with plant which may give rise to a hazardous situation shall be designed to requirements with electrical connection safety barriers or intrinsically safe equipment. Where required by the Owner/Owner's representative, certification shall be provided to confirm the suitability of the equipment and devices.

The Contractor shall be responsible for ensuring that all electrical equipment installed in any hazardous zone is designed and tested to suit the relevant zone classification and shall be to the approval of the Owner/Owner's representative. Cables shall not be laid in trenches with fuel pipe work.

**Fire protection provisions**

Unless otherwise specified or agreed with the Owner/Owner's representative, the following design principles should be observed as minimum fire prevention requirements:

Pipeline insulation and the infills of cable and pipeline wall penetrations are to be of non-combustible material.

All pipelines or vessels with internal temperatures of more than 180 °C shall be so arranged as to avoid any contact with flammable liquids if fuel or lube oil lines should leak. Sufficient physical separation shall be ensured.

Particular care should be taken to eliminate any risk of hot pipeline-insulating material becoming impregnated with flammable liquids in the case of fuel or lube oil line leakage. The insulation is to be covered in its entirety, with an oil resistant sheet, over which the cladding is to be fitted.


Cable and pipeline ducts must be so arranged and sealed as to avoid any risk of flooding with, lube oil or any other flammable liquid. In addition to sealing the cable and pipeline ducts, the cable basements must be completely sealed against leakage from above as well, in order to preclude the ingress of lube oil or other flammable liquids.

Covered floor ducts must be easily accessible for inspection and cleaning.

All parts of plant and equipment are to be arranged so that no corners or pits that would be difficult to inspect and clean and in which flammable matter could collect are formed.

Fuel pre-heating temperatures shall be limited to a margin of atleast 10K below the fuel flash point.

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Lubricating oil lines in the turbine-generator lube oil system are not to be connected with compression-type joints but rather with welded or screwed-type points.

Non-combustible materials which do not release noxious or toxic fumes must be used for wall and ceiling panelling, for floor covering, and for cubicles and cabinets.

**7.0.0 GENERAL PLANT DESIGN REQUIREMENTS**

**7.1.0 General**

The design of the combined cycle power plant consisting of GT, ST & Generator, HRSGs and associated auxiliaries shall generally conform to the following requirements and shall be new and unused.

The plant shall be constructed considering prudent engineering practices and optimal utilization of resources. These shall be complete and include all the equipment and systems necessary to ensure required level of reliability, availability, efficiency, and high level of safety and maintainability over their lifetime. It is also necessary to consider various precautions to safeguard the operating and maintenance personnel.

The Plant shall be suitable for full range of ambient and other environmental conditions as per specified site conditions in this contract. The design of the power plant shall ensure that the plant can, in the state of normal operation, adapt itself to load, frequency, power factor, ambient variations within the allowable range of design and the Grid Code requirements.

The auxiliary systems and plant facilities shall be designed for serving the whole power plant with adequate redundancy. The redundancies shall be provided as specified in this Contract. Secondary system component shall be designed with suitable redundancy (redundancies are as specified in this Contract) in order to achieve the required reliability and availability of the power plant.


The life span to be considered for the design of equipment and component selection shall be at least 25 years and components which are not meeting this requirement shall be identified and its life shall be guaranteed, specifically in the Contract. Due to operation requirement, the plant components or parts will have definite material life span requiring replacement on more frequent basis, which needs to be recognized. Certain components like electronic parts, DCS, bearings, components subjected to wear and tear etc. will have a definite life span which will be less than 25 years. These components have lower shelf life and the life of the equipment needs to be prolonged by replacement of these components.

The various parts and systems of the power plant shall be designed to achieve the object of providing integrated and coordinated power plant operations. For the design of the power plant, it is necessary not only to consider the requirements of operation, but also, by suitably planning the layout, the convenience for inspection, cleaning, maintenance and repair are ensured.

The various parts or components or assemblies of equipment and systems shall be of proven materials with well established physical and chemical properties appropriate to the service as intended.

All materials, components and equipment shall be tested at all stages of procurement, manufacturing, erection, commissioning as per comprehensive Quality Assurance Programme to be agreed mutually between the Owner/Owner's representative and the equipment supplier.

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In the design of the power plant and selection of equipment, the specific requirements of this project and likely occurrences of abnormal operating conditions (The abnormal conditions are, 1. During fluctuations in grid frequency and voltage (within the specified limits as specified in the specifications) 2. During load swings (from minimum stable operating load to base load) without any restrictions in operation). have to be taken into consideration to ensure that the power plant can, under these circumstances, operate continuously, safely and without undue loss of efficiency. The selection of materials shall be suited to local operating and ambient conditions.

Equipment installed outdoors shall be capable to operate in all-weather conditions and withstand the work site environment.

The equipment must operate without undue vibrations that may affect its operation/life and that of other machinery or of civil works under every condition.

Corresponding parts throughout the plant shall be made to gauge and be interchangeable for all models of same duty. The supplier shall provide the necessary original part references for all kinds of parts of equipment.

All equipment performing similar duties shall be of the same type and manufacture in order to limit the stock of spare parts required and maintain uniformity of plant and equipment to be installed to the extent feasible. Exact requirement, if feasible, will be ascertained during detail engineering.

The design & construction of plant shall be such that it is suitable to comply with all applicable environmental stipulations of the Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB) including in regards to flue gas emissions, liquid effluent discharges, solid waste disposal, noise levels.

The plant site is in the coastal area, hence the environment is likely to be corrosive and the materials of construction for all exposed metal/ concrete surfaces shall be so chosen as to withstand the corrosive environment. Also suitable weather protection shall be provided to all exposed surfaces. Underground piping shall be provided with suitable anti-corrosive measures.


All stand-by auxiliaries shall be designed for auto start up, on failure of running auxiliaries with minimum time delay and without runback on unit load.

All heavy parts of the plant must be provided with some convenient arrangement for aligning and for handling during erection and overhaul. Any item of plant required to be stripped or lifted during period of maintenance and weighing one tonne or more shall be marked with its approximate weight.

**7.2.0 Standards and Codes of Practice**

All equipment, systems and works covered under these specifications shall be in accordance with all the applicable statutes, regulations, codes and standard specified as well as all such standards, statutes, regulations and safety codes applicable in the locality where the equipment will be installed. Contractor may familiarize themselves with all such requirements. Complete design including pressure parts, piping, valves and fittings shall meet or exceed all the latest requirements of the Indian Boiler Regulations (IBR), latest Indian Standards /ASME codes, latest codes and standards as applicable . Any Indian/International standards shall be followed for any imported equipment. For plant layout aspects and area classification requirements OISD standards shall be followed.


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The design, construction and testing of all equipment, facilities, components and systems shall be in accordance with relevant standards and codes issued by Bureau of Indian Standards (BIS) and/or reputed international standards and codes as on the date of Award of Contract. A non-exhaustive list of reputed international standards is given below:

- a) American National Standards Institute (ANSI)
- b) American Petroleum Institute (API)
- c) American Society of Mechanical Engineers (ASME)
- d) American Society of Testing and Materials (ASTM)
- e) American Water Works Association (AWWA)
- f) American Welding Society (AWS)
- g) British Standards (BS)
- h) Cooling Technology Institute (CTI)
- i) Deutsches Institut fur Normung (DIN), Germany
- j) Gosstandart of Russia (GOST) standards
- k) Heat Exchange Institute (HEI), USA
- l) Hydraulic Institute Standards (HIS), USA
- m) International Electro-technical Commission (IEC)
- n) Institute of Electrical and Electronics Engineers (IEEE)
- o) International Organisation for Standardisation (ISO)
- p) Japanese Industrial Standards (JIS)
- q) National Electric Code (NEC), USA
- r) National Electrical Manufacturers Association (NEMA), USA
- s) Central Electricity Authority (Construction of Electrical Plants and Electric Lines) Regulations, Notification, 20<sup>th</sup> August 2010 and to those referred therein
- t) National Fire Protection Association (NFPA), USA
- u) Occupational Safety and Health Administration (OSHA)
- v) Tubular Exchanger Manufacturers Association (TEMA), USA
- w) VDE association for Electrical, Electronic and Information Technologies (VDE), Germany
- x) OISD

Other international Standards, equivalent or superior to the above Standards can also be adopted. However, In the event of any conflict between the requirements of the international

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standards or codes and the requirements of the BIS standards or codes, the latter shall govern unless specified elsewhere in the specifications. Any Indian/International standards shall be followed for imported equipments.

The Plants and Electric Lines (within the plant) shall also be designed to comply with the requirements stipulated in.

- a) Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006.
- b) Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007.
- c) Central Electricity Authority (Measures relating to Safety and Electricity Supply), Regulations as and when these are notified by the Authority.
- d) Central Electricity Authority (Safety Requirements for Construction, Operation and Maintenance of Electrical Plants and Electric Lines) Regulations as and when these are notified by the Authority.
- e) Central Electricity Authority (Grid Standards) Regulations as and when these are notified by the Authority.
- f) Central Electricity Authority (Construction of Electrical Plants and Electric Lines) Regulations, Notification, 20<sup>th</sup> August 2010 and to those referred therein
- g) Indian Electricity Grid Code issued by Central Electricity Regulatory Commission (CERC) and
- h) Applicable State Grid Code issued by appropriate Regulatory Commission.


All material and equipment supplied and all work carried out as well as calculation sheets, drawings, quality and class of equipment, methods of inspection, constructional peculiarities of equipment and parts and acceptances of partial plants, as far as these are beyond the special requirements of the specifications, shall comply in every respect with the technical codes of the above listed codes and Standards.

It shall be the responsibility of the Contractor to take all approvals required and get the HRSG registered under the IBR. In all other cases where IBR does not govern, IS/ASME, Japanese, American, British, German or other international standards established to be equivalent or superior to IS/ASME shall be acceptable with the approval of the Owner/Owner's representative at the time of detailed engineering.

Where there are no standards or regulations, or the standard is not sufficient to meet the need of design and supply, for such items relating to the power plant, the Contractor shall carry out the design, manufacture, supply and installation on the basis of good engineering practice.

During the period of Contract execution, if any standards change, the Contractor shall be responsible to notify the Owner/Owner's representative and provide the basis for the prospect that it would not cause the lowering of quality, performance and service life of the power plant due to alteration of the standard and the latest standards shall be followed by the Contractor.

Further requirements about applicable standards and codes are specified in the detailed technical specifications.

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**7.3.0 Operating Capabilities**

The power plant will be operated in parallel with the grid normally at base loads as required and as permissible by the Original Equipment designs, but meeting the requirement of the Grid Code in all cases considering the fuel specified.

Combined cycle module, comprising of Gas Turbine, Steam Turbine, Generator and HRSG , shall deliver its Guaranteed Gross Power Output of 51 MW (Minimum) at the specified Site Reference Conditions and with the specified fuels & utilities at the guaranteed Gross Heat Rate at the time it is tested as per the Contract and thereafter with normal and reasonable degradations (as provided by MPP), performance will be subject to degradation as per MPP supplied curves.) where applicable considering the planned inspection and maintenance as proposed by the Contractor in the Contract without any undeclared expiry of life expectancy.

All combined cycle plant equipment sizing shall be carried out considering the maximum unrestricted gross power output.

In all cases it is understood that the plant will be operated & maintained by qualified professionals utilizing the Operation instruction and the Routine & Preventive Maintenance instructions as specified by the MPP and Planned Maintenance will be conducted under the supervision of MPP utilizing the parts acceptable by the MPP. It is also understood that Operator actions in case of emergency situations will be as per prudent industrial practices in India.

The unit shall be designed for constant pressure and sliding pressure operation.

The gas turbine, steam turbine and all rotating auxiliaries shall be suitable (That is offered equipment and it's arrangement in relation with other connected equipment should have been already validated) for continuous operation within the frequency range of 47.5 Hz to 51.5 Hz.

All the auxiliary equipment and the drive motors shall be capable of delivering satisfactorily their actual output continuously for voltage variation, frequency variation and combined voltage and frequency variation as indicated elsewhere in the specification.

The design of the equipment and control system shall be suitable for operation of the CCGT module in automatic load frequency control.

The design shall cover adequate provision for quick start up and loading of the unit to full load at a fast rate. The ST loading or unloading shall be in line with the recommendations of MPP.


The unit shall be capable of automatically coming down to house load and operation at this load in the event of sudden external load throw off.

There shall be a HP and LP bypass system to facilitate quick starting and loading under hot restart conditions and to facilitate conserving condensate where too many start ups occur. Owing to certain conditions in the system, part load operation of the machine could occur for prolonged durations. Under such conditions there shall not be any undue deterioration in the parts and the elements. The turbine unit shall be capable of deriving economic benefits due to lower temperature of inlet air to GT as per ISO conditions, circulating water and environment in winter.

**7.4.0 Vibration**

Vibration shall be reduced to the minimum as far as possible where it cannot be completely eliminated. Amplitude and frequency limitation in the design and supporting structure shall be considered for vibration, The variation in grid frequency to be considered for vibration design

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shall be 47.5 Hz to 51.5 Hz. Also verification of structures for their natural frequencies shall be carried out by Contractor.

Special care shall be taken to avoid operating equipment making resonance with foundations, packing, duct, platform, piping or other components.

Unless otherwise stated or agreed by the Owner/Owner's representative, each rotating machine has to comply with the requirements for designation as 'good' stipulated by ISO standard for the respective group of machinery. If the vibration is higher than stipulated as 'satisfactory' the Owner/Owner's representative has the right to reject the corresponding equipment, subject to the conditions specified elsewhere.

### 7.5.0 Noise levels

The plant shall be designed and constructed to reduce the operating noise level as much as possible and when the plant is operating at all loads, the noise pressure levels specified in Section 17-Environmental Requirements shall not be exceeded. Any noise emanating from any protective systems such as ST bypass, and safety valve is excluded. For background noise from the existing plant, noise levels will be measured before commencing the test for proposed plant,

- a) Noise level at the Property boundary shall not exceed the Ambient Air Quality Standard in respect of noise as stipulated by CPCB and SPCB in this regard.
- b) Noise level for the continuously operating equipment including GT, ST & Generator, BFP, and CWP shall not be more than 85 dB(A) at a distance of 1 metre and at a height of 1.5 metre from any equipment. For short term exposure, noise levels shall not exceed the limits as stipulated in the Occupational Safety and Health Administration (OSHA) Standard.
- c) For control room and offices, noise level shall not exceed 60 dB (A) near to the duct and at other places in the control room/offices noise levels shall not exceed 50 dB (A).
- d) Equipment/ machines shall be provided with acoustic enclosures, wherever required so as not to exceed the permissible noise limits.

### 7.6.0 Units of Measurement


For all the technical tables and diagrams, calculation results, drawings, test data and scales adopted in the design and provided for the power plant, the standard international unit system (SI) as per International Standardization Organization (ISO) shall be uniformly employed.

SI system shall be employed for all the plant layout and arrangement drawings of equipment made especially for the project.

### 7.7.0 Safety

For this Project, Contractor shall have a dedicated Safety and Health Section, within the Project Team. The dedicated Safety and Health Section shall monitor all safety and health related activities at the site.

The construction site shall have one qualified officer responsible for health and safety co-ordination. He will be assisted by requisite numbers of safety supervisors and firemen to ensure smooth progress of work at site. This person shall ensure that safe and healthy working practices are implemented and maintained. A pro-active health and safety programme shall be implemented that provides the following for all Contractors' workers:

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- a) Policy statement, philosophy, objectives and targets, procedures and training that are compiled to produce a Health and Safety Plan;
- b) A minimum of one (1) health and safety awareness meeting per month for all personnel; and a minimum of two (2) health and safety preview meeting per month for construction supervisors and designated health and safety personnel to assess the programme's effectiveness and implement improvements as necessary;
- c) Continuous health and safety performances monitoring and audits;
- d) Weekly health and safety statistics reporting;
- e) First aid facilities and personnel; and
- f) Procedures for responding to emergency situations.

The Contractor shall furnish and issue approved safety helmets, safety boots, safety belts, protective goggles, protective clothing, breathing equipment, as applicable, to all workmen and authorised personnel during the course of hazardous construction of all types.

The Contractor shall provide and properly maintain warning signs and lights, barricades, railings, and other safeguards for the protection of personnel as required by the conditions and progress of the work.

Special importance shall be assigned to all aspects related with the safety of personnel operating, assembling and maintaining the equipment, including other persons who are likely to come in contact with same.

The possibilities of human failure must be foreseen. Provisions shall be taken to avoid damage caused by human error or to ensure that such damage both to persons as well as to the equipment is the least possible.

Rotating or any other moving part of the machinery, hot parts or any part that may cause accident to the staff must be adequately protected, in accordance with the safest method known.


All components with surface temperatures exceeding 60°C shall be fitted with insulation to protect personnel. The surface temperature shall not exceed 60°C if the condition of the ambient temperature is 40°C and wind velocity is 1 m/s.

However if there are any hot spots such as connection of expansion joint to duct, where the surface temperature may exceed 60 deg. [C], suitable personal protection for the hot spot on exhaust duct shall be provided.

Bright paints used will be agreed upon with the Owner/Owner's representative to protect personnel, so that anything representing a potential danger will stand out: such as elements in movement, suspended hot, with electric tension.

It should be possible to carry out routine maintenance operations required by the equipment without interrupting its operation and without danger to the personnel.

Access stairs to the equipment must be safe, with anti-skid rungs and handrail. Normal circulation areas of the equipment shall be protected to keep personnel from falling or shall be surrounded by strong guardrails, platforms should have kicking plates to keep loose objects placed on the floor from dropping off, entrances and large openings in the equipment

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shall be provided with lids or doors affixed in such a way as to open them also from the inside.

Every equipment or parts of equipment that must operate under certain conditions of maximum pressure, temperature, speed, position, should have devices to keep such limits from being exceeded and, if necessary, to stop the operation of the machine (Safety valves, limit switches, thermal switches).

For protection against the possible failure of the above devices, additional safety elements shall be provided such as stroke limiting stops, diaphragms, bolts and/or links or other dimensioned rupture elements so that in case of failure, when exceeding extreme operating conditions, additional safety is provided to the equipment.

Inside air and gas ducts, ladders have to be installed for inspection of dampers, venturies.

In designing an area where combustible gases are likely to accumulate, due consideration shall be given to provide safety measures to allow the gas to continuously diffuse or leak off to prevent explosion. The electric equipment in those areas shall be of the fireproof and explosion proof type. Suitable grounding shall be provided on the casing of electrical apparatus which might be energized.

Draining of water and venting of gas shall be performed with respect to the safe mode of discharge, and is not allowed to be carried out at or near the places where people exit and at the exit of the plant.

**7.8.0 Fire Protection and precautions**

The Contractor shall adopt necessary methods to minimize fire hazards.

The fire protection system shall in general follow the recommendation of TAC / NFPA / OISD standards. However, GT CO<sub>2</sub> Fire detection and protection system will be designed and supplied based on NFPA 12, IS – 2189/ NFPA-72.

The design of power plant shall include a complete set of composite fire monitoring, protection, and fighting system to identify, isolate, and distinguish fires as well as minimizing potential fire hazards.


A warning alarm for the power plant and alarm for evacuation shall be provided. The alarm is to be audible in the normal working areas of personnel. The selection of the alarming device shall be such that it is audible about the normal background noise of the plant. Visual alarm shall be provided in addition to audio alarms in high noise areas.

During the construction phase of power plant, the Contractor adopts advanced and safe working practices and a set of guidelines to keep the site in a clean condition to reduce the possibility of fire. The basic guiding ideology is to adopt two methods: fire prevention and fire control shall adopt to improve conditions in designing the layout, to reduce potential fire danger, ensure the safety of personnel, ensure the safety of the important and main equipment of the power plant.

Use fire proof or fire resistant materials ensuring that isolating combustible material is not used or stored in possible fire source area of the power plant.

The end connection type of hydrant shall fit in with local fire brigade requirements to ensure the manual device in power plant to be compatible with the fire control device of local fire brigade.

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**7.9.0 Signs**

Safety colours, safety symbols and safety signs must comply in construction, geometrical form, colour and meaning with the ISO Recommendation 507 of the ISO committee TC 80 'Safety Colours'. All signs should give the identification number. All signs shall be in the English language.

The signs should be of a material which is weather-resistant and of sufficient durability for the conditions prevailing on site. Indian regulations and codes are to be considered.

The positions for the signs must be chosen so that they are within the field of vision of the persons to whom they apply. The signs should be permanently attached. Temporarily dangerous areas (e.g. construction sites, assembly areas) may also be marked by movable signs. The safety signs must be mounted or installed in such a manner that there is no possibility of misunderstanding.

All Necessary Traffic signs, Information sign, Emergency sign, Mandatory signs, Warning sign, Prohibition sign viz., No Smoking, No Entry, Do Not Start, shall be provided at appropriate area in the entire power plant area.

**7.10.0 Package, Storage and Store House**

The Contractor should provide all the specifications and instructions for the self purchased and fabricated equipment during the planning period of the Contract. These specifications should include the cleanliness and maintenance requirements of materials during fabrication and the protection measures for the equipment from damage during transportation. Loss of materials during storage should be avoided before installation. The instruction should be worked out especially to suit the particular work site program.

All materials and equipment should be packaged according to the typical environmental conditions during storage. In case of severe conditions, these materials and equipment should be packaged carefully by taking a full and appropriate preventive measure to protect from any damage or wear.

The Contractor and his appointed Subcontractor for installation should guarantee jointly that a good supplementary storage will be carried out within the equipment site controlled by them.

Three classes for storehouse are described as follows:

Storehouse class A items: Special measures are taken to protect the stored goods and the temperature, humidity are controlled within a specified range.


Storehouse class B items: Goods are stored with temperature uncontrolled.

Storehouse class C items: It is an outdoor storage with a drainage system on the ground.

For storehouses of class A and B they should be fireproof, heat resisting, waterproof and well ventilated. They should not be wet and should be provided with good drainage system and preferably with a brick laying or concrete ground. For storehouses of class C, they should not be wet and should be well drained, preferably with a brick laying or crushed stone ground, should be protected from rainfall, salt corrosion, ash and other adverse conditions with a temporary cover or tent if possible.

Component surfaces should not be contacted directly with the ground or ground laying material. There should be a layer of oilcloth or wax or other similar materials between the machine surface and ground surface.

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All components shall be inspected for their painting, storing, sealing and any damage or wear should be repaired during acceptance and storage periodically. The inspection interval is determined by the component function, applied protection measure and storehouse class.

Many components are provided with a drying agent or sealed in a coverage (polyethylene or insulating cover) containing drying agent. The drying condition shall be inspected during storage in an interval of every 4 weeks.

**7.11.0 Painting, Insulation, Anti-dewing**

Anti corrosive coatings and painting shall be carried out as a pre-treatment to all equipment and parts. The paint system used should coordinate with the painted objects and surrounding conditions of project.

In multi-layer painting system, different painting layers should be selected to make the painting coordinate. If multi-layer painting system is used, various painting layers should have distinct colours so that the later layer can be distinguished from the former one.

After the equipment or apparatus finished preliminary or full painting, it can be supplied to field. After the installation is finished, ground coat must be painted.

Entire painting procedure should be supplied in order to repair the injures of painting coat after the equipment is delivered to field.

Colour strip indication system should be used for pipes. These strips should be painted on the joint of pipes, entrance, valves of pipe. This pipe without outside protection layer should be marked by some colour in whole length. **Refer Annexure-3 (Vol-IV,Sec-8) for the color coding of piping and fire equipments.**

The principal colour of field equipment should be determined by Owner/Owner's representative and Contractor during execution stage. For Electrical equipment, paint shade shall be as mentioned in the equipment Specification.

Further requirements with regard to painting, insulation, and anti-dewing are specified in the relevant sections in the detailed technical specifications. The specified requirements shall be applied to the whole equipment and facilities of the Contract.

Insulation specification for MPP supplied equipment shall be as mentioned in detailed technical specification.

**7.12.0 Language to be used**

English shall be used as the general Contract language English translations shall be provided for any code and standards not in English language.

Name plates of equipment and instrument scale shall be marked in English.


Documents for training shall be provided in English.

Danger signs / Exit signs shall be in English, Hindi and Gujarati.

**7.13.0 General Mechanical Requirements**

This section covers the general mechanical requirements of all other sections of this specification and shall be complied with in every respect unless otherwise stated or agreed by

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the Owner/Owner's representative. Further requirements to be applied are specified in the detailed technical specifications.

**7.13.1 Castings and Forgings**

The quality requirements of approved international other national standards shall be taken as the minimum requirements.

Cast iron is not to be used for any part of equipment which is in tension or which is subjected to impact, or to a working temperature exceeding 100°C unless specifically approved by the Owner/Owner's representative. Materials for iron castings shall comply with approved international or national standards.

All forgings are to be manufactured from basic electric steel or fully killed acid open-hearth steel. Consideration shall be given to the use of vacuum-degassed steels in appropriate cases.

Forgings shall be free of cracks externally or internally, extensive non-metallic inclusions and surface defects which cannot be removed by subsequent machining.

Each forging shall be suitably branded with an identification number which shall be transferred throughout all final machining stages. The identification number shall be marked on all documents and test certificates relative to the forging.

**7.13.2 Pumps**

The following represents general requirements for pumps Intended for various services and the same shall be read in conjunction with the requirement specified elsewhere in the detailed specifications.

**General**

All pumps shall be so designed that they are suitable for continuous operation unless otherwise specified.

Pumps installed for parallel operation or as standby sets are to be of the same design, i.e. interchangeable (Subject to application, fluid handled and identical model).


Standard-type pumps with suitable characteristics shall be used wherever practical. Only proven makes and models are to be supplied to the extent feasible. All accessories and the overall design of pump sets are to be such that they are suitable for automatic operation as specified for the relevant systems.

All pumps shall comply with the applicable recommendations of Hydraulic Institute Standards (U.S.A) or approved equivalents (Latest codes and latest standards as applicable). Special pumps which are designed only as per manufacturer standard shall be identified and stated in the bid. Deviations to the specified Standard if any shall be subjected to approval by the Owner/Owner's representative prior to ordering the same. Owner/Owner's representative understands that deviations to the standard are to be recognized, but the reputation of the OEM, past performance at similar application and fit for the purpose consideration are the only considerations in accepting the deviations.

**Pump types**

Centrifugal pumps shall be used wherever possible.

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Rotary-type positive displacement pumps will be accepted for handling viscous liquids, and reciprocating/plunger pumps will be accepted for chemical dosing and metering purposes

All pumps shall have a continuously rising head (up to shut-off) characteristics with the minimum shut-off head of 115% but not exceeding 125% of the head at best efficiency point for the rated impeller.

The pump shall be designed to have best efficiency between the rated and normal point. However in no case the rated point should be beyond 115 % of the best efficiency point.

Contractor shall note that the pump characteristics as obtained during the performance testing of pump shall not deviate from the characteristic furnished during earlier stages of approval particularly with regard to the operating point and shut off head and steepness of the curve beyond the duty point. Pump characteristic curve can be furnished during detailed engineering stage after finalization of specific vendor.

All large capacity and continuously operating pumps shall have 5% flow and head margin each, and all other pumps shall have flow and head margins of 10% and 15% respectively unless specifically stated otherwise in the detailed specification

The pump shall be capable of meeting the actual requirement for continuous operation at 47.5 Hz.

The equipment shall be made suitable for outdoor installation (this shall be applicable for pumps intended to be located outdoors). Weather/environmental conditions under which the equipment must operate are specified in the 'Project Data'. However, for the Owner/Owner's representative's guidance, the contractor shall list any special protection that the Owner/Owner's representative is required to arrange.

Pump shall be capable of automatic start up from stand still condition with discharge valve fully open in general. Motor shall be selected according to the above requirement.

Difference in flows handled by the two pumps when operating in parallel shall not be more than 5% of the flow through any one pump.

The impeller shall be of non-overloading type, Overloading type of impellers are acceptable for BFPs and CEPs, however the motor shall be designed taking this into consideration and shall be suitable for run out flow.

A hardness difference of 50 BHN minimum shall be maintained between the impeller ring and wearing ring, inter-stage bushing and spacer sleeve and balancing and spacer sleeve and Balancing disc/piston and counter balancing disc.


Mechanical seal of shall be provided at both ends of the shaft of pump for DM water/ Feedwater/ Condensate.

The maximum temperature rise of bearings shall not exceed as per standard over ambient temperature.

All major rotating components shall be dynamically balanced. The assembled rotors shall be dynamically balanced.

The Contractor shall also demonstrate that the pump can operate at the quoted minimum continuous stable flow without exceeding the vibration limits as stipulated in HIS.

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Pump-motor set shall run smooth without undue noise and vibration .The limits of vibrations shall be applicable with maximum wearing clearances.

Acceptance of the forced lubrication system shall be subjected to the approval by the Owner/Owner's representative. Forced oil lubrication system provided for HP/LP BFPs shall be supplied with separate AC driven lube oil pumps, lube oil plant with interconnecting piping and controls. Acceptable peak to peak vibration limits shall generally be guided by HIS.

The drive motor rating shall be selected such that a minimum margin of 25% up to 18.5KW, 15% for 22-55KW, 10% for above 75 KW is available over the pump input power required at the rated duty point. However, motor rating shall not be less than the maximum power required by the pump at any point on the curve including the run-off condition.

**7.13.3 Piping and Appurtenances**

All the skid mounted equipment piping wherever specified shall be in fully assembled condition. Piping shall be duly supported on the base plate and terminated with ANSI flange at the edge of the base plate towards suction. Piping shall be properly tagged with metallic strips.

In mechanical seal cooler, cooling water shall be used on shell side. Tube shall be made of SS304.Shell shall be of carbon steel. Tubes used for cooling bearing housing shall be of SS 304.

Forced oil lubrication when used shall have all supply lines in stainless steel (from downstream of strainers) and return lines in carbon steel.

MPP supplied piping and Appurtenances shall be as per MPP standards.

The technical and design features of each is elaborated in a separate section.

**7.13.4 Suction Strainer**

Strainer shall be provided on suction line of each pump except for DM water application. Generally Basket type strainer is preferred .The clear area of strainer shall be five times the inlet cross sectional area of the connecting piping. Strainers shall be constructed of 16 gauge perforated stainless steel plates (304grade) and shall be lined with stainless steel (316 grade) screen.

The design pressure for strainers shall corresponding to maximum system pressure envisaged during the worst operating condition

The pressure drop across the strainers at rated flow under 100% cleaned condition and 50% clogged condition shall not exceed 0.1 kg/cm<sup>2</sup> (max.) and 0.15 kg/cm<sup>2</sup> (max.) respectively.

The strainer shall be so designed that they all capable of sustaining the differential pressure at rated design flow and 50% clogged condition.


Suction Strainers supplied by MPP shall be as per MPP Standard.

**7.13.5 Welding**

All welding / cutting / rework on IBR piping shall be strictly done as per IBR code.

All welding process shall be of standard and internationally agreed type and designation free from all unproven innovative or development features

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All costs for inspection and testing including any additional tests required by the Owner/Owner's representative shall be deemed to be included in the Contract Price. Any additional inspection and testing required by the Owner/Owner's representative shall be performed promptly and no claims for consequent delay or disruption of the work will be considered. All tests shall be conducted as per finally approved QAP. There is no additional test required other than mentioned in the QAP.

The procedure to be followed in production welding of all parts of the vessel including main seam, circumferential seams, and branches shall be provided in detail by the Contractor for the Owner's /Owner's representative's approval.

Welding, post weld heat treatment and other non-destructive testing shall be conducted by Contractor as required by the ASME and as instructed by the Owner/Owner's representative. Procedures of all welding, welder qualification and treatment of welding defects, pre/post welding heat treatment, NDT shall be performed after welding as per ASME and Testing requirement shall be approved by Owner/Owner's representative. Contractor shall arrange suitable stress relieving equipment with automatic recording device.

All necessary radiography as per applicable code shall be included in the scope of work of the Contractor.

Approval of the welding procedure shall not relieve the Contractor of his responsibility for correct welding, electrodes and for minimising distortion in the finished structure.

All welders and welding operators shall be qualified for the work and shall hold current welder's qualification certificates in accordance with the ASME Sec. IX and IBR.

For welding on site, the Contractor shall provide drying ovens in sufficient number to permit the correct storage of electrodes for 48 hours before use. Drying ovens shall preferably be heated by electric means and shall have automatic heat controls and visual temperature indication. The storage temperature for electrodes shall be as stated by the manufacturer but in the case of low hydrogen electrodes shall not be less than 100 °C. The re-baking of low hydrogen electrodes shall be strictly in accordance with the manufacturer's recommendations.

Welds of stainless or special steel with steel which is not stainless must be made in a manner which ensures that the stainless steel or special steels do not lose their corrosion-resistant or other special properties.


Welded seams shall not be painted before inspection; in case of necessity, only colourless coating may be used.

All controls, examinations and tests corresponding to these specifications, shall be performed by the supplier, without detriment to the Owner's/ Owner's representative's inspection right to verify and control them on their part or to repeat them if they deem it is necessary.

The supplier shall keep 'welding records' for all pressure pipes with a qualified welding method, as well as for condensers, deaerators, water pipes, pressure vessels and other important weldings. He shall record on them, after every working day, the number of weldings executed during the day, their location, identification of welders, measured preheating temperature (if any) and other information of interest.

The Inspector shall be notified at regular site meetings at least 2 days prior to the commencement of any assembly or fabrication work.

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All control protocols, such as of the qualifications of welders and methods, of evaluation of x-rays, of magnaflux examinations, as well as the x-ray films, shall be submitted to the Owner / Owner's representative's inspection for their approval at appropriate time.

**Qualification of welders**

The standard to be applied for the qualification of welders shall be approved by the Owner/Owner's representative. Welders shall be qualified according to the section IX of the before mentioned ASME standard. The inspector of the Owner's / Owner's representative's has the right to attend during the qualification tests. Tests with unsatisfactory results made by a welder under qualification may be repeated by him doubling the number of tests (This will be reviewed case by case during detailed engineering). For the welders acceptance each of the repetition tests has to be satisfactory. The supplier shall keep a 'registry of welders' on which he shall record systematically: qualifications, part of the supply on which they intervene, major faults and comments.

**Qualification of methods**

The variables to be considered in defining the weldings subjected to special qualification of method shall be agreed upon with the Owner/Owner's representative. Stipulations in Q-11, section IX, of the mentioned ASME standard, shall govern for this purposes.

**Control of executed weldings**

Unless otherwise agreed or unless other contractual stipulations exist, the section VIII, point UW 51 of the ASME standards, shall apply for 100 % x-ray controls, and the point UW 52 for x-ray sampling examinations, excepting from the last the indications about porosity which shall be agreed upon separately.

The Contractor shall have at the works site all necessary equipments and facilities to perform control, like portable x-ray equipments, radioactive isotope equipments, x-ray laboratory, magnaflux equipment, dye check penetrants and developers, fluorescent power and ultraviolet lamp to verify the watertightness of expanded tubes. The Contractor's personnel shall include a specialist and the auxiliary workers necessary to execute the controls.

**7.13.6 Lubrication**


Lubricated elements shall have a safety reserve against occasional lubricating deficiencies or their retaining capacity should be such as to operate without damage even if delays occur during maintenance periods. As far as possible, lubrication of the given element in the machine should be done with the same lubricant under all climatic conditions (winter and summer) and furthermore, a limited number of different types of lubricants should be required for the different parts of the equipment. Lubrication oil and grease of any brand shall be easily obtained on the local market in India. This requirement will be ascertained during detailed engineering and outcome of this will be informed to Owner/Owner's representative.

Where centralised lubrication system is provided then it shall include purification of the main lubricant by centrifugal or static filter.

Lubricant deposits such as those on bearings, accumulation tanks, should be easily accessible, simple to clean and to control their level and it should be possible to empty their contents.

The required lubricant characteristics shall be stated, also indicating the trade name for the products.

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**7.13.7 Vessels, Tanks and heat exchanger**

All pressure vessels shall be designed in accordance with ASME Boiler and Pressure Vessel, Section VIII Unfired Pressure Vessels. All butt welds shall be subject to radiography test as per ASME relevant code and all other welds shall be subject to 100% non destructive testing. Other standards the Contractor intends to use are to prior approval of the Owner/ Owner's representative. All flanged connections to pressure vessels shall conform to at least pressure class 150. Threaded connections shall conform to pressure class 300. MPP supplied vessels, tank and heat exchangers shall be as per MPP standards.

All connections shall match for pipe instrumentation, drains and relief valves. All bolt holes must straddle the centre line of nozzles. Access stairways and handrails necessary for safe operation and easy maintenance shall be provided. Corrosion allowance shall be considered for carbon steel material. However, in case of coating or rubber lining or SS material, corrosion allowance will not be applicable.

If any degree of vacuum may occur the pressure vessel or tank shall be designed for full vacuum even if vacuum breakers are installed.

The items listed below shall be provided as a minimum.

- One(1) manhole (minimum nominal bore 600 mm) for vessels of 1.0 meter diameter and above
- Two(2) handholes (minimum size 200 mm) for vessels below 1.0 meter diameter.
- Two(2) spare nozzles
- One(1) drain nozzle

Manhole covers shall be provided with davit arrangement.

The saddle and reinforcing plates welded to the vessel shall be of the same material as the vessel shell or head. Insulated vertical vessels and tanks shall be furnished with insulation supports or clips.

**Tanks**

Unless otherwise specified, tanks used for the storage, lubricating oil, make-up water, condensate, chemicals. and tanks used for mixing and agitation shall be of welded construction, manufactured from mild steel plates of accepted quality and thickness in accordance with the approved relevant standards.

All welds shall be continuous, including welds around internal stays, stiffeners and supports.

All large tanks shall have at least two manholes each of 600 mm inner diameter complete with covers of the bolted type, fitted with a davit for easy handling.


All tank nozzles shall be provided with flanges, if not otherwise specified.

Nozzles shall be provided where necessary for the fitting of instruments, and piping.

Internal and external protection coating/painting of the tanks shall be performed according to the requirements of this Contract.

Arrangements shall be made for the blanking-off or removal of all valves or pipe connections during shot-blasting and painting to prevent the ingress of blasting material or other matter.

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The protective process shall be applied also to any ferrous or non-ferrous parts mounted inside the tanks.

**Heat exchanger**

Heat exchangers are to be designed, manufactured and erected in accordance with the applicable standards.

Only proven products shall be delivered. No cast iron components are permitted.

It must be possible to install and remove the heat exchangers without undue difficulty. Lifting lugs and eyes and other special tackle shall be provided to permit easy handling.

Only Tubular heat exchangers are acceptable. Where necessary the tubes are to be protected by impact shields. An adequate number of visual inspection ports is to be provided in critical areas to facilitate condition monitoring.

Unless otherwise specified, all heat exchanger tubes and casings must be designed to withstand 1.2 times the zero flow pressure of the relevant pump at cold conditions, or 1.2 times of the maximum positive operating pressure, as applicable. The minimum design pressure is 6 bar, and the design shall be proof against full vacuum. The test pressure must be 1.5 times the design pressure.

The heat exchangers shall be designed for the maximum temperature incurred plus 20 K except for MPP Supplied Heat exchangers. For MPP supplied heat exchangers the design temperature shall be as per MPP standard design philosophy.

Heat exchangers must be capable of continuous unrestricted operation with up to 10% of plugged tubes, and a corresponding factor of conservatism of at least this amount must be used in the design of the heat transfer areas. However, plug margin for Condenser shall be as per Detailed Technical Specification (DTS).

Considerable importance will be attached to the ease of cleaning the heat exchangers.

Where any heat exchanger part in contact with liquid can be isolated, and there is a possibility of being heated from the other side, safety valves are to be provided for pressure relief.

Pipes from drains, vents and safety valves are to be grouped together, and routed to easily observable points equipped with covered funnels or to the flash tanks.

The overall design and conception of the heat exchangers and accessories is to be such that they are suitable for the degree of automation envisaged for the individual system.

**7.13.8 Cranes and Hoists**


Cranes and hoists are to be designed in accordance with the applicable Indian and International Standards.

The crane installations must be supplied with all the ropes, chains, shackles. needed for operation.

The minimum scope of supply per hoist for each lifting tackle includes the following items:

- four (4) single ropes each with 2 eyes at the ends, each rope 1 m long
- four (4) single ropes each with 2 eyes at the ends, each rope 2 m long

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- two (2) single ropes each with 2 eyes at the ends, each rope 4 m long
- two (2) endless ropes, extended length 4 m each
- eight (8) shackles.
- 2 Sets of soft/synthetic slings of suitable capacity for handling generator rotor of GTG and STG.

The load-bearing capacity of the ropes and shackles must be suitable for the relevant hoist.

The maximum tension in the rope must not exceed 1/8 of the calculated breaking capacity of the rope. The ropes must be of the stranded type, and galvanized wires must be used.

The eyes of the single ropes must be secured with compression fittings. The length of the eyes must be at least 15 times the nominal diameter of the rope.

In special cases, where safe lifting of the relevant component is not certain, specially-made devices must be provided. At least two (2) of these must be provided in each individual case.

For each installation a list must be submitted, showing the number, type, nominal load-carrying capacity and strength characteristics of the materials used. In addition, factory and acceptance certificates must be submitted for all ropes and materials.

The safe lifting capacity of lifts is to be clearly marked stating both the maximum load in kg and the number of persons the lift was designed for. For this purpose the weight of a standard person shall be taken to be 75 kg.

For Design data for lifting devices for MPP supplied equipment shall be as per MPP standard, refer the detailed technical specification.

**7.13.9 Elevator**

One (1) no. elevator with a carrying capacity of ten (10) passengers shall be provided for the Switchgear / control building.

**7.14.0 General Electrical Requirements**


All equipment supplied and all work done including system design and detailed engineering shall also comply with the statutory requirements of the State/Central government and with the Indian Electricity Rules.

Unless otherwise specified, at least 10 % margin shall be considered in equipment sizing over and above the calculated load current/fault current/power requirements.

If not specified otherwise the electrical operational equipment must be designed to meet protection classes stated below.

- |  |   |       |
|--|---|-------|
| • HT Switchgear (Indoor)                     | - | IP 4X |
| • LT Switchgear (Indoor)                     | - | IP 52 |
| • Control panels (Indoor)                    | - | IP 42 |
| • Relay panel                                | - | IP 42 |
| • Motors (indoor)                            | - | IP 54 |
| • Motors and other equipment located outdoor | - | IP 55 |
| • Emergency DG (Indoor)                      | - | IP 23 |

Each individual enclosure accommodating electrical equipment which is liable to suffer from internal condensation due to atmospheric or load variations shall be fitted with heating

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devices suitable for electrical operation at AC single phase. Heaters in switchgear / control cubicles, panels, desks shall be controlled automatically by thermostats.

Motors rated 0.2 kW and below, except otherwise required for reversible service, shall be rated for use on a 240 V, single phase, 50 Hz, solidly grounded system. Motors rated above 0.2 kW and up to 160 kW shall be rated for use on 415V, 3 phase, 50 Hz, solidly grounded system. Motors above 160 kW shall be rated for use on a 11 kV, 3 phase, 50 Hz resistance grounded system. All Motors shall be designed for direct on line starting at full voltage.

Electrical motor operated actuators shall have non- integral starters.

Guards shall be provided for protection of personnel from all exposed moving and/or rotating machine elements. Necessary supports and accessories shall be furnished with each guard to prevent vibration. Guards for outdoor installation shall be galvanized steel. Grease fittings shall be extended through the safety guards.

For all other requirements of electrical system, the respective electrical sectionals shall be referred.

**7.15.0 General Control and Instrumentation (C&I) Requirements**

The Instrumentation and control systems shall be provided for safe, reliable and efficient operation of the combined cycle power plant. In general a consistent control and instrumentation philosophy is to be applied throughout the power plant. Standardization concepts shall be applied wherever possible to rationalize operation, maintenance and reduce spare parts. Adequate redundancy are to be ensured, so that no single point failure of the I&C systems/ equipments in the power plant results in the overall reduction of the plant output.

For the turbine control package standard control/protection system shall provide no single failure of field sensor cause Unit to trip. Redundant sensors shall be provided for control / protection functions with the exception of functions used only during start-up and where redundancy cannot be provided due to limitation in installation space. Also final control elements (trip solenoids and fuel valves) themselves and related accessories shall not meet this requirement.


In general all I&C systems/ equipments should be of modern and compact design, incorporating proven technology and modern industrial practice.

**7.16.0 General Civil Requirements**

The design specification covered in Section 5 of Vol-III establish the minimum basic requirements for all Civil structural and Architectural works. However all structures shall be designed for the satisfactory performance of the function for which the same are to be constructed.

With regard to soil and other hydrographic data furnished, it shall be clearly understood that the same are given to the Contractor in good faith and as such no claim for extra payment shall be entertained by the Owner/Owner's representative, if the actual condition met with during execution are at variance with the data given in Contract. The Contractor shall fully satisfy himself about the site conditions,nature of soil,ground water,contour levels etc,prior to the submission of the bid.The contractor shall conduct his own investigations to ascertain the correctness of the data furnished and based on the actual data the Contractor shall finalise the most suitable civil and structural design basis, which will be submitted to Owner/Owner's representative for review & approval.

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**7.17.0 List of Approved Sub-vendors**

Refer Volume IV/Annexure-1/ Section 8.

With full information substantiating the technical acceptability of the proposed change. The Owner/Owner's representative's decision shall be final. Concessions granted shall not absolve the Contractor from any of his responsibilities under the Contract.

**8.0.0 QUALITY ASSURANCE, SHOP INSPECTION AND TESTING**

**8.1.0 General**

This section contains general requirements for inspection of material, parts, equipment and workmanship of the plant during manufacture, assembling to demonstrate compliance with specification, codes and standards to ensure overall reliability of plant operation and performance.

The Owner/Owner's representative and/or authorised Representatives shall, at any time, be allowed free and ready access to the Contractor's premises and those of his suppliers as well as to the site installation and the Contractor has to make the plant items available for the purpose of inspecting the specified equipment components and obtaining information as to the progress of the work. Failure on the part of the Owner/Owner's representative, at this or any other time, to discover or reject materials or work which do not meet specified requirements shall not be deemed an acceptance thereof nor a waiver of defects therein.

The approval of the Owner/Owner's representative shall not prejudice the right to reject equipment if it does not give complete satisfaction in service.


**8.2.0 Scope**

All materials, components and equipments covered under this specification shall be tested at all stages of procurement, manufacturing, erection, commissioning as per a comprehensive quality assurance programme. The requirements of minimum quality plans to be followed by the Bidder in respect of various equipment are specified in detailed technical specification. The Bidder shall draw his own quality plans in line with these requirements and his standard practices and implement such programme after approval by the Owner/Owner's representative. The Owner/Owner's representative shall appoint a Third party inspection (TPI) agency for bought out items/outside inspection. The Owner/Owner's representative will carry out on-site supervision and inspection.

Manufacturing quality plan shall detail out, for all the components and equipments, various tests/inspection to be carried out as per the requirements of this specification and standards mentioned therein and quality practices and procedures followed by contractor's quality control organization, the relevant reference document and standards, acceptance norms and inspection documents raised. during all stages of material procurement, manufacture, assembly and final testing/performance testing.

The Contractor has primary responsibility for ensuring the quality of items of equipment supplied under the contract and remains accountable when manufacture or erection is subcontracted. It is therefore a requirement of the specification that work is only subcontracted to companies with effective quality control organization and that the Contractor monitors the performance of these by the attendance at tests of experienced inspectors employed by the Contractor. The Contractor shall, at the appropriate time, prove that his

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material and / or equipment comply with all the requirements of this Section, such proof being the successful completion of tests and inspections. Routine test and type test certificates shall be submitted for each item of equipment, wherever applicable.

All materials, components and equipment supplied under the contract shall be subject to inspection by the Owner/Owner's representative, his representative, Inspectors of Boilers (India) or his authorized Agency or any other Inspector of the Government, should they so require during manufacture, erection and after completion. The necessary inspection charges of the authorized agency of Inspection of Boilers (India) shall be borne by the contractor. The inspection and tests shall include but shall not be limited to the requirements of this section of the specification. Further requirements to be applied are specified in the detailed specification.

The Bidder along with quality plan, shall also furnish copies of the reference documents/plant standards/acceptance norms/test and inspection procedure referred by him in quality plans. These quality plans and reference documents/standards will be subject to Owner/ Owner's representative's approval and will form a part of the contract. In these approved quality plans, Owner/Owner's representative shall identify customer hold points (CHP), indicating tests/checks which shall be carried out in presence of the Owner/Owner's representative's or authorized representative and beyond which work will not proceed without consent of Owner/Owner's representative's in writing.

No materials/equipment shall be dispatched from the manufacturer's works before the same is either accepted subsequent to pre-dispatch final inspection including verification of records of all previous tests/inspections by Owner/Owner's representative or such pre-dispatch final inspection is waived by the Owner/Owner's representative and dispatch is authorized after review of test reports.

All materials used or supplied shall be accompanied by valid and approved material certificates and test and inspection reports duly approved by the Owner/Owner's representative. These certificates and reports shall indicate the acceptable identification number of the material they proposed to certify. The material certified shall also have the identification details stamped on it.

All material used for equipment construction including castings and forgings shall be of tested quality as per relevant codes/standards. Details of results of the test conducted to determine the mechanical properties, chemical analysis and details of heat treatment procedures recommended and actually followed shall be recorded on certificates and time temperature chart. Tests shall be carried out as per applicable material standards and/or as specified in detailed specification.


All welding shall be carried out as per welding procedure drawn and qualified in accordance with requirements of ASME Section IX. Welding procedures shall be submitted to the Owner/Owner's representative for approval prior to carrying out qualification test in the presence of I/Owner/Owner's representative

All welders/welding operators employed on any part of the contract either in the Supplier's works or at site or elsewhere shall be qualified as per ASME Section-IX.

Test results of qualification tests and specimen testing shall be furnished to the Owner /Owner's representative for approval. However, wherever required by the Owner/ Owner's representative, tests shall be conducted in presence of Owner/Owner's representative

All the heat treatment results shall be recorded on time temperature charts and verified with recommended regimes.

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All the sub-vendors proposed by the Bidder for procurement of major bought out items including castings, forgings, pumps, heat exchangers, semi finished and finished components/equipment-(list of which shall be drawn up by the Bidder along with his offer and finalized with the Owner/Owner's representative) shall be subject to Owner/ Owner's representative's approval.

The type and extent of inspection of items shall be in accordance with the relevant International/Indian Standards/Indian Boiler Regulations and other standards approved by the Owner/Owner's representative, supplemented or amended by the requirements of this section of the specification or as specified elsewhere in the Specification.

**8.3.0 Inspection Program and Test Notifications**

Before manufacturing commences and not later than 45 days after award of contract, the Contractor shall submit an outline of his proposed inspection program, which shall include all major stages during manufacturing. The inspection and test program shall include for the various items the designation No., name of equipment, part of equipment, the kind of test, test standard, company which carries out the test, place, date and witnesses by the Contractor, third party or Owner/Owner's representative's .

The Owner/Owner's representative will return a copy of the Contractor's proposed inspection program indicating those inspection stages for which notification is required. Notification shall be by Fax or email in a format to be agreed and shall be sent at least 20 days prior to the intended test in accordance with 'Conditions of Contract'. If the Owner/Owner's representative intends to be represented at the test he will provide at least 24 hours' notice and if his representative does not attend on the notified date, the test may proceed unless an alternative date has been requested by the Owner/Owner's representative.

**8.4.0 Test Certificate Documentation**

The results of all tests shall be certified by the manufacturer, Contractor or independent agency as appropriate.

Document files containing material certificates, welding procedures, test report shall be compiled for each item of plant and shall be suitably identified (including equipment classification reference) and bound.


Three copies of each document file containing inspection reports and certificates of site erection testing activities of a particular item of plant or system shall be supplied to the Owner/Owner's representative prior to commissioning.

Copies of the performance and acceptance test reports shall be prepared and distributed as specified in Clause 'Performance and acceptance test data and reports' of this Section. All documentation as required by IBR shall also be prepared and submitted.

**8.5.0 Certification of Equipment by Owner/Owner's representative's**

The Personal and travelling costs in connection with the Owner/Owner's representative's inspection and witnessing of tests of equipment, components and material manufactured in India and abroad will be borne by the Owner/Owner's representative.

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**8.6.0 Codes and Standards**

**8.6.1 General**

The type and extent of inspection shall generally be in accordance with that specified in the standard used for design and construction of the item of equipment supplemented or amended by the requirements of this section of the specification. The Contractor should provide the relevant codes and standard to the Owner/Owner's representative.

**8.6.2 Reference to Codes and Standards**

Reference to special codes and standards, where designated either directly or as "relevant", is intended to provide a measure of performance, safety, in-shop and on-site testing, and methods of construction and/or installation which must be equalled or exceeded in order to be considered acceptable for use under this specification. If more than a single degree of quality or accuracy is permitted within the scope of particular code or standard, the highest quality shall be applicable and the degree of accuracy commensurate with the intended function shall be selected, but with the understanding that the final decision will be made by the Owner/Owner's representative.

In all instances, the finally accepted applicable code or standard shall be the version last published.

**8.6.3 Alternative Standards**

Where no appropriate standard is available, tests shall be conducted in accordance with the manufacturer's standard practice, subject to the approval of the Owner/Owner's representative.

In such cases the Contractor shall submit to the Owner/Owner's representative, complete data and a suggested procedure for the testing to be performed. Commencement of manufacture before receipt of the Owner/Owner's representative's approval shall be at the Contractor's risk.

If the proposed procedures are accepted, the Contractor shall provide the Owner/Owner's representative with four additional copies in English before any test is performed.

**8.6.4 Derating Standards**


The Contractor's attention is drawn to the climatic conditions in the site area. Derating factors shall apply in accordance with the relevant and approved standards if not specified in the contract documents.

**8.7.0 Services prior to and During Inspection and Testing**

In accordance with and in addition to specified standards the Contractor shall submit procedures for material testing, manufacture, quality control and performance testing as they apply from the procurement phase of raw materials to the finished product. Manufacture commenced before receipt of the Owner/Owner's representative's approval of material specifications and testing procedures shall be at the Contractor's risk.

No inspection shall be valid unless the Contractor and manufacturer are in possession of relevant approved drawings and procedures for the item to be tested. The Contractor on

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request shall supply the Owner/Owner's representative's with a copy of drawings and procedures at the time of the test.

All instruments and apparatus required for the inspection or used for the performance of tests shall be subject to the approval of the Owner/Owner's representative at his discretion and shall be calibrated to an agreed standard in approved laboratories. The cost of making such calibrations shall be borne by the Contractor in all cases.

If the Contractor wishes to apply for a concession in respect of a departure from an approved procedure or standard, this shall be made in writing with full information substantiating the technical acceptability of the proposed change. The Owner/Owner's representative's decision shall be final. Concessions granted shall not absolve the Contractor from any of his responsibilities under the Contract.

**8.8.0 Testing During Manufacturing**

The minimum testing requirements for mechanical, electrical and C&I equipment testing to be conducted at manufacturer's works are specified in the detailed specifications.

**9.0.0 EQUIPMENT ERECTION, SITE TESTING, COMMISSIONING AND PERFORMANCE TEST**

This Specification generally covers the standards, scope of works, documentation, scope of installation, testing and commissioning of various mechanical, electrical, control and instrumentation equipment & system and various requirements to be adhered to during the execution of the works.

Works shall be performed in accordance with this technical specification and various other drawings and schedules submitted and approved by the Owner/Owner's representative during the execution and the instructions from Engineer-in-charge or his authorized representatives during the progress of the work. Consumables required for the job shall be ensured by the Contractor. All necessary equipments and instruments required to carry out the works, recalibration of the instruments required during loop checking and commissioning shall be done by the contractor.

Field quality plans shall be submitted and shall detail out for all the equipments, the quality practices and procedure to be followed by the Contractor's site quality control organization during various stages of site activities including receipt of materials/equipments at site, preservation and storage, pre-assembly, erection, pre-commissioning and commissioning. The Contractor shall provide all necessary means for execution of inspection and testing, according to the requirements.


**9.1.0 Erection**

**9.1.1 General**

Erection work shall be carried out in the manner and sequence as may be directed by Contractors supervisory Engineers and the Owner/Owner's representative.

All existing structures, piping, conduits, equipment and facilities shall be protected by the Contractor against damage/degrade during erection. Any damage/degradation caused by Contractor shall be rectified at his cost to the satisfaction of the Owner/Owner's representative within short timelines.

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As erection proceeds each assembled part before being boxed up with a view to erecting it finally, shall be inspected and approved by the concerned supervisor. Should any defect be found out during such inspection, the Contractor shall make it good as per directives from Owner/Owner's representative.

All materials such as electrodes, gaskets, bolts, nuts shall be of reputed make and conforming to relevant Indian Standards. Prior approval of Owner/Owner's representative will have to be obtained before commencement of work. Manufacturer's test certificate shall have to be provided when called for.

Contractor shall furnish all instruments, isotopes, films for conducting radiography and equip himself fully. Necessary operators of all testing equipment shall be provided by the Contractor. Dark room facilities with air conditioners for storing and processing radiography films and equipment, as necessary, shall have to be arranged by the Contractor. The radiography shall be done on any weld (including welds for repair) only after final heat treatment.

The equipment shall be placed on respective support, levelled and aligned with precision measuring instruments, checked for proper clearance between moving and stationary parts wherever applicable.

The installation of motors shall be carried out along with driven equipment in accordance with manufacturer's instructions and/or as directed by the Owner/Owner's representative.

Wherever the scope includes control panels, all connections in control panels shall be completed, checked and adjusted to ensure safety and satisfactory operation of the equipment.

Particular attention shall be given towards removal of buckles and other forms of distortion.

Holes in plate work to assist in erection should be avoided.

Misalignment in vertical joints shall not exceed 10% of plate thickness or 1.0 mm, whichever is larger.

Misalignment in horizontal joints shall not exceed 15% of upper plate thickness with a maximum of 2 mm for plate thickness above 8 mm and a maximum of 1.0 mm for plate thickness less than 8 mm.


Welding sequence shall be adopted in such a way so as to minimise distortion due to weld shrinkage and shall be got approved from the Owner/Owner's representative prior to commencement of work.

Welding shall not be carried out on wet surfaces and shall be protected from high winds.

**9.1.2 Erection Program and notification**

The Contractor shall furnish a detailed erection programme taking into consideration the constraints likely to be encountered during various phases of work including interfacing with the existing plant. This erection programme shall be strictly adhered. The Contractor shall take appropriate steps as directed by the Owner/Owner's representative to make up for any slippage from this erection programme and no additional compensation shall be allowed on this account.

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Before erection commences and not later than three months before start of erection, the Contractor shall submit the proposed erection test program and the commissioning test program with all proposed erection and commissioning tests and checks. Together with the test programs the proposed test procedures have to be submitted.

The test programs should consider:

- that the sequence and duration of the proposed activities are logical, realistic and in accordance with safety and permit regulations in force
- that the commissioning of any item of plant would not interrupt the normal operation of the existing plant.
- that allowance for training the Owner/Owner's representative's operation personnel during this period has been made.

The Contractor has to take care that the test programs are maintained by the erection organization during erection and commissioning.

The Contractor has to mark all stages, which are subject to the Owner/Owner's representative's acceptance and has to notify at least two week's in advance when such inspection for acceptance becomes due.

### 9.1.3 Supervision during Erection

The Contractor shall provide at proper time the necessary supervisory Engineers, Supervisors and other supervisory personnel duly qualified and in sufficient number for transportation, handling, unloading, storage, erection, pre-commissioning and post commissioning, startup, testing and test operation of plants and equipment.


The Contractor shall keep a competent representative who will be resident Engineer-in-charge and shall remain as In-charge of Contractor's work site and also remain answerable to the Owner/Owner's representative for all activities of the Contractor at site. Before his placement at site, the Contractor shall submit his bio-data to the Owner/Owner's representative for his approval.

The Resident Engineer-in-charge shall supervise the work of all men of the Contractor working at site. He shall work in complete harmony and co-operation with Owner/Owner's representative. All statutory rules and labour laws prevailing in the area must be observed by the Contractor. All safety measures against occurrence of accidents must be taken effectively. Resident Engineer-in-charge shall not be withdrawn without written permission of the Owner/Owner's representative. If any of the Contractor's personnel was found unsuitable for the job, the Contractor shall remove him forthwith and a suitable replacement shall be posted to site within a reasonable time. No compensation for withdrawing of unsuitable or unqualified person(s) from site or for posting suitable person(s) to site at any stage of the project shall be allowed by the Owner/Owner's representative.

### 9.1.4 Sequence of Erection Work

All packing cases and packages shall be opened in presence of the Owner/Owner's representative or his authorised representative.

Nails and packing strips should be pulled out with suitable appliances and kept separately in container and not thrown away at random. All timber of packing cases shall have to be sorted out and stored properly at a suitable place as directed by the Owner/Owner's representative.

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From time to time packing materials, timber, nails and strips shall be delivered back to the Owner/Owner's representative or otherwise disposed of as directed by the Owner/Owner's representative. All timber and packing materials shall remain the property of the Owner/Owner's representative.

Each material after stripping from boxes or received loose, shall be carefully inspected, checked with shipping list and identified with erection drawing if necessary. Any short supply and/or damaged part shall be reported forthwith to the Owner/Owner's representative in writing. The Contractor shall be completely responsible to make all necessary arrangements, application and follow procedure to process claim on underwriters, obtain replacement repair/rectify and modify as required on all such damaged/defective/lost equipment and material at no extra cost to the Owner/Owner's representative in order to execute the work to satisfaction of the Owner/Owner's representative within the stipulated contract time. Once the materials are inspected, the same shall be preserved properly and adequately protected from theft and deterioration or damage by rain, storm, dust, water, tampering by casual visitors or workers. The Contractor shall prepare and maintain stores, ledgers and bin cards for all materials in his custody.

Carrying out all repairs to damages/degradation that might have occurred during transit and in subsequent storage. Also modifications and rectification work as necessary and replacement of all lost parts, are under the Contractor's scope.

**9.1.5 Safety Regulations**

Contractor should follow all the safety regulations / norms as imposed by the Law/Authority/factory inspectorate /Owner/Owner's representative. When going to or from place of work in the plant only the prescribed walkways, paths or cross-overs shall be used and required protections, barricades shall be established for the plant area.

Crawling on, over or under movable equipment shall generally be prohibited.

For overhead work, proper signs shall be placed below and, when conditions justify, a watchman shall be stationed to warn employees in the vicinity.

Work on or about crane runways shall not be undertaken without the Owner/Owner's representative's permission. Whenever it is necessary to do any work on or above the crane runways, the Contractor shall furnish a flag man stationed on the floor.

Only scaffolds which meet the requirements of governing laws shall be used in the project.

Work in area of electric wires and cables shall generally be avoided.

All burning and welding equipment shall conform to, and be used in accordance with, regulations governing such equipment. No burning or welding shall be done at any place on the site until location where such work is to be done is approved.


Adequate fire protection shall be available before work preceding the work.

All warning signs shall be observed.

Contractor shall require his employees to wear hard hats at all times when they are inside the plant area.

Goggles shall be worn whenever there is a possibility of flying particles or splashing of corrosive fluid.

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While working at site all workmen shall wear necessary safety protective equipment.

When ladders are the means of access to a platform, they shall be firmly secured top and bottom and the ladder rails shall extend at least one meter above the top landing. When a ladder cannot be secured, a man shall be stationed at the base.

Safety belts shall be used by men working in high places when no hand rails or other guards are in place.

All accidents resulting in injury shall be reported to the Owner/Owner's representative promptly. Owner/Owner's representative's safety rules, regulations and directives shall be followed and reports thereon shall be submitted as and when required.

**9.1.6 Proper Treatment of Injured**

Contractor shall ensure that proper treatment of injuries is immediately available either as such or in the form of constantly available transportation to a source of such treatment.

Contractor shall ensure that stretchers are available near all areas in which their men are working and that the location of stretchers are well marked.

Contractor shall be solely responsible for the dissemination of all safety regulations including those written here, those promulgated by Owner/Owner's representative and those dictated by good practice, and shall ensure that all his employees and those of his Sub-Contractors are conversant with same

**9.2.0 Inspection**


After completion of erection and/or installations and before start-up the equipment and all its appurtenances shall be thoroughly cleaned and then, inspected in the presence of the Owner/Owner's representative for correctness, soundness and completeness of installation and acceptability for start-up.

All works to be carried out by the Contractor shall be subject to inspection by the / Owner/Owner's representative as applicable. The work shall be carried out as per applicable specifications, codes of practice, drawings and instructions of Owner/Owner's representative . The Contractor shall provide necessary facilities, instruments and personnel for carrying out the inspection as above and shall comply with the instructions given.

A check list in triplicate will be furnished for the approval of Owner/Owner's representative wherein all items to be checked and necessary instructions will be listed. Inspection and checking shall strictly follow this check list. On completion of the joint inspection and checking two (2) copies of the check list will have to be handed over to the Owner/Owner's representative. The check lists after checking will have to be jointly signed by the Contractor's supervisor and the Owner/Owner's representative to ensure that all inspection and checking have been properly carried out. However, such endorsement shall not relieve the Contractor from the responsibility in ensuring proper erection and cleaning.

During inspection all clearance, alignment and important measurements and adjustments as may be directed shall be noted by the Contractor for future reference and guidance. Two (2) copies of such notes shall be delivered to the Owner/Owner's representative.

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All reports of radiographic examination in a format approved by the Owner/Owner's representative shall be submitted to the Owner/Owner's representative for his approval and records.

**9.2.1 Cleaning**

The Contractor shall observe strict cleanliness during execution of the work and shall be in possession of vacuum cleaner for cleaning the internals of machinery under installation. They shall check that all the finished surfaces are greased and covered.

Before boxing up, the Contractor shall examine carefully to ensure that no foreign material, such as welding rod ends, welding beads, metal chips, rope, working tools has been left inside any equipment.

In the case of motors, the following procedure shall be observed

- a. Checking and cleaning of bearings and charging / filling of lubricants, wherever necessary.
- b. Cleaning of core and winding, drying out and cornicing the winding and measurement of air gap for motor assembled at site.

Wherever the scope includes control panels, all withdrawable components shall be taken out and internals shall be cleaned with vacuum cleaner, if required.

**9.3.0 Testing and Commissioning**

**9.3.1 Erection Test**

Following the satisfactory completion of inspection, checking and cleaning of a unit, the plant will be placed in test run. During this period, all adjustments and repairs as required shall be made by the Contractor. Protocol shall be made and signature has to be obtained from Owner/Owner's representative. On completion of satisfactory test run, the plant will be placed under trial operation.


Prior to trial operation of any equipment the following shall be checked:

During erection all required erection tests as well as final erection checks of the mechanical completion of the systems and part thereof have to be performed.

After successful mechanical completion Mechanical Completion Certificates will be issued.

The activities necessary for mechanical completion shall include but not be limited to following testing:

- Visual inspection after unloading at site
- Checking of completion of relevant systems
- Proper installation of the drive and equipment on the foundation
- Proper alignment of drive and the driven equipment
- Proper connection of supports, hangers, piping, valves, instruments and other fittings.
- Freeness of the rotors of drive and equipment
- Healthiness of lube oil system, changing and filling as necessary.
- Safety audit
- Testing of site welds (non-destructive examinations)

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- Pressure/leak/tightness test
- Pipe line and equipment flushing and cleaning
- Chemical protection of piping systems
- Checking of coating
- Testing of cranes and hoists
- Safety signs and warning signs
- Completion of buildings and civil works
- Test of ventilating and air-conditioning units

**Electrical/instrumentation equipment tests**

The following checks and tests measurements shall be made:

- Screwed connections for correct assembly
- Terminals and terminal connections for correct assembly
- Checking of earthing connections and testing of earthing resistances
- Measurement of insulation values
- Verification of neutralization conditions
- Fire-proof partitioning
- Marking, inscription, provision of designation plates
- Voltage checks
- Polarity checks in the case of DC voltages
- Fuses, over current trips, short-circuit trips, time settings, relay settings
- Transformer oil levels
- Setting indicators, revertive (check-back) signals to the central control room.
- Checks on wiring and cabling for conformity with the constructional circuit-drawings and plans
- checking and functionality testing of electrical systems according to IEC standards
- checking and testing of instruments

**9.3.2 Pre-Commissioning Testing**

After alignment of all equipment, alignment tests shall be carried out by the Contractor to check levelling, clearance, eccentricity. Measurements will be witnessed and acceptance will be certified by the Owner/Owner’s representative.


Hydro-test / eddy current test, as applicable will be carried out on equipment as identified in the QAP to be finalized during detailed engineering. . All necessary blanking arrangements for hydro testing shall be furnished by the Contractor. All necessary test pump/temporary piping shall be supplied by the Contractor.

Preconditions for the commissioning are the issue of the Mechanical Completion Certificate and the availability of the accepted commissioning program and the Contractor’s commissioning procedures. The Pre-commissioning Checks cover the functional tests of the individual items and their alarm and tripping systems. Following tests shall be included:

**Mechanical equipment**

- Individual pre-commissioning runs of all rotating equipment such as pumps, compressors, dosing equipment.
- functional tests of the mechanical equipment
- Testing and adjustment of safety devices.

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### Chemical Cleaning of Piping Systems and Equipment

Necessary procedure for chemical cleaning of piping and equipment shall be submitted to Owner/Owner's representative for their approval along with pre-commissioning document during detail engineering stage.

Before introducing chemicals, all the piping systems and equipment shall be water flushed. Water flushing will be followed by alkaline cleaning, acid cleaning and passivation or by EDTA (Ethylene Diamene Tetra Acid) and passivation.

However, the Contractor shall submit along with the offer his usual procedures and practices for chemical cleaning of the piping and equipment specified. The Contractor shall submit all schematics, write up, details of chemicals to be used. and detailed procedures he intends to follow. These schematics and procedures shall be subject to the approval of the Owner/Owner's representative.

#### Pre- cleaning procedure:

Prior to starting any phase of cleaning operation the following procedures shall be ensured:

Installation of all temporary piping, valves, pumps and equipments as required for the flushing and chemical cleaning operations. Temporary piping shall be routed at floor level as far as possible and secured in place to prevent movement/ vibration beyond acceptable limits.

Installation of the instruments as required to ensure satisfactory monitoring and control of the cleaning process. The Contractor shall also determine and arrange locations for sampling of the cleaning solution during cleaning.

By passing all regulation/control valves coming in the cleaning circuit or installation of temporary spool pieces.

Installation of special end covers and temporary suction strainers, for boiler feed pumps and condensate pumps. Pump internals shall not be installed.


Installation of plastic seal in the condenser neck to protect the turbine from alkaline fumes.

Blocking and securing of all spring hangers in the steam lines which may be flooded during the cleaning operation.

Hand cleaning of the interiors of all vessels which are included in the cleaning operation.

#### General cleaning procedures:


- a) Seal water lines to pump shall be flushed by the permanent arrangement provided for the same.
- b) Where pipeline terminate in spray headers, these headers shall be inspected after each phase of the cleaning operation and cleaned if necessary.
- c) All strainers shall be observed closely during the cleaning operation by reading differential pressure gauges, and shall be cleaned when the differential pressure exceeds a predetermined value.
- d) All high points, vents shall be opened periodically to ensure full system flow.

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- e) Upon completion of each stage of cleaning, the waste products shall be drained and transferred to the waste treatment basins. The Contractor shall then supply and add the necessary chemicals to the basin to neutralise all waste solutions and rinses generated by the cleaning process, and arrange for its disposal to an area to be indicated by the Owner/Owner's representative.
- f) Strict safety precautions shall be exercised at all times during the chemical cleaning and during storage and handling of the chemicals. The Contractor shall ensure provision of all protective clothing, apparatus and equipment along with necessary first aid kits as required for handling the chemical and for carrying out the cleaning operation.
- g) All Hazardous waste material generated during construction, erection and commissioning shall be disposed by Contractor using authorised waste disposal agency.

**Steam Blowing of Piping Systems**

- i) Steam blowing shall include engineering, supply and installation of all temporary piping, valves, fittings including quick actuating valves (for puffing purposes), supports, blanking plates, spools, target plates, instruments, controls and all other accessories and services required to complete the cleaning process as specified herein
- ii) The detailed schemes and procedure for steam blowing operations shall be prepared and furnished by the contractor and discussed and finalized during the detailed engineering stage.
- iii) Steam blowing shall also include reinstatement of cleaned piping systems; and dismantling/removal of all temporary piping, equipment and materials from site. All temporary piping, valves, equipment and materials shall be taken back by the contractor upon satisfactory completion of cleaning, and shall be removed from the Owner/Owner's representative's premises.
- iv) Engineering involved regarding temporary piping shall include the following:
  - a. Selection of temporary piping including disturbance factor calculation.
  - b. Preparation of layout of temporary piping and performing stress analysis as per ANSI B 31.1.
  - c. Selection of temporary hangers and supports as required.
- v) The following piping systems shall be cleaned through steam blowing operation.
  - a) Main steam, , LP, HP and LP bypass and process steam piping system.
  - b) Auxiliary steam piping system.
- vi) Steam blowing shall be carried out for removal of particles (rust, scales, weld splatter) from various piping systems to avoid damage to turbine bladings. Cleanliness of system shall be checked by means of test plates made of steel, which will be installed in the centre line of the piping system.
- vii) Cleaning shall be achieved by steam purging i.e. by blowing of steam through the piping such that the momentum of flow is greater than that of steam flow during normal operation of unit (at TMCR). The disturbance factor during steam blowing (ratio of momentum of flow during purge to that during TMCR) shall be more than 1.4.
- viii) The blow off shall be done with steam, which is exhausted through adequately sized, open-ended temporary piping. Temporary piping and motor operated valves shall be installed for steam blowing operation. Pressure shall be built up in the boiler and the

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pipings warmed before release of steam by quick opening of motor operated valve located on temporary piping. The cycle shall be repeated until steam from the blow out pipe is determined to be clean.

- ix) If the flow nozzles and control valves have already been erected these shall be removed and replaced by spool pieces before steam blowing. The removed flow nozzle and control valves shall be put back after steam blowing.
- x) The motor operated valves used for steam blowing shall have special characteristics like minimum loss of pressure, resistance to wear during severe working conditions (high velocity and carryover of water and solid particles), quick opening time, minimum effort on electric actuator.
- xi) The steam blowing termination criteria shall be as under:
  - a) Acceptable target plate condition
  - b) Measured disturbance factor (DF) more than 1.4 ((to be reviewed and decided during detailed engineering stage depending upon type of cleaning adopted by Contractor Acid/alkali boil-out).

The required values to calculate actual DF will be measured at site. The criteria for acceptable target plate condition shall be finalised during detailed engineering.

**Electrical equipment**


As far as not already covered by the erection tests the pre-commissioning tests shall cover:

- High voltage tests
- trip tests
- Equipment Functional Test

**Tests on Motors** as per IS

- Insulation test of winding by megger, drying out and, if necessary, high potential test.
- Winding resistance measurement on all 3 phases for motors of bigger size.
- Testing the motor for proper direction of rotation and reconnection, if necessary.
- No load test run of the motor for a minimum of eight (8) hours to check out bearing or other associated parts.
- During test run, hourly record of currents on all the three phases shall be maintained and careful watch shall be maintained on the equipment for any abnormal sound, temperature of bearing, vibrations.
- After no load test run of the motor each rotary equipment shall be coupled and shall be subjected to a test run. The duration of this test run shall be mutually agreed.
- The objective of the test run shall be to ascertain that the following are within the permissible limits and the operation is satisfactory.
  - Vibration and noise level
  - Bearing vibration and temperature
  - Performance of the lube oil systems

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- Motor winding temperature
- Performance of various control, interlocks and protective elements, wherever applicable.
- Performance of annunciation system and indication, wherever applicable.

**Tests on transformers**

During installation : Checking of complete delivery, checking of core earthing and insulation of active part from tank, H.V. sample tests of transformer Oil in accordance with IEC or equivalent Standards.

During commissioning : Checking of satisfactory operation.

**Tests on earthing and lightning protection system**

Acceptance tests and measurements of the earthing installations in accordance with IEC or IS standards.

**Tests on lighting system**

Proof of the minimum new value of lighting densities, checking of correct operation both electrically and mechanically.

Contractor shall provide the list of site tests to be performed on electrical equipment as part of pre-commissioning activities for Owner/Owner's representative's review.

**Control Equipment**


- Calibration tests of all analog measuring loops including all remote indications and recorders and the input signals used for closed loop control.
- Testing of all plant mounted transmitters.
- Wiring test of all control cabling in the field, control rooms combined with the function tests.
- Testing of all control modules in the control room

Functional testing of remote control of drives, circuit breakers, solenoid valves, actuators etc.

- Testing of open loop devices especially all sequence logic equipment using simulated inputs.

Testing of all interlocks to ensure safe operation.

- Testing of the alarm annunciation and event recorder system in connection with all field and control room devices using simulated inputs.
- Testing of all closed loop controls.
- Testing of insulation between cable screen and ground.

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**9.3.3 Commissioning**

Preconditions of the commissioning are the successful completion of the pre-commissioning checks of all items of the whole system.

Commissioning tests shall be performed in accordance with the procedure contained in the commissioning program approved by the Owner/Owner's representative for individual equipment/system and as a plant. Commissioning test shall also include Redundancy and automatic fall back by simulation of fault conditions

On completion of each commissioning activity to the satisfaction of the Owner/Owner's representative, the commissioning schedule shall be signed and dated by the Contractor and countersigned by the Owner/Owner's representative.


Commissioning test shall prove that the plant is prepared and adjusted to ensure the correct functioning of the individual components and of the complete plant.

After successful completion of the commissioning tests "Authorization to Performance Test " shall be signed.

The Commissioning test shall cover at least following tests:

- Protection tests
- operation of protection devices including the following as a minimum
  - fire protection
  - HRSG protection
  - Gas turbine protection
  - steam turbine protection
  - generator protection
  - transformer protection
  - 66kV GIS protection
  - Balance of plant protection
- Method of alarm/trip condition reset for subsequent starting Isolation procedures method of isolation of plant equipment for safe shut-down and maintenance procedures including as a minimum
  - HV station and unit supplies
  - LV supplies
- Protection systems/settings, in accordance with agreed design and the requirements of the transmission system
- Start-up tests
  - Normal automatic start to preset load
  - Staged automatic including start to synchronous speed, manual synchronizing (including synchro-check), automatic synchronizing, manual and automatic loading
  - Starting with stand-by auxiliaries
  - Operation of all auxiliaries
  - Verification of start-up times and loading rates of power units and steam generators at various conditions
  - Power unit(s), test partial and full load rejection to demonstrate.

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- Full load rejection tests to measure transient maximum speed and steady state speed at normal governor droop setting
  - Method of resynchronism to be demonstrated.
- Turbine bypass operation capability
  - Demonstration of start up of the plant utilising start up power only from black start DG and demonstration of safe shut down utilising DG for emergency purposes.
  - Operating stability when operated in the full range of load conditions with load variations by increasing or decreasing the electric load/steam delivery.
  - Demonstration of the capabilities of the Power Units to operate at rated voltage and frequency, at power factors and reactive conditions between 0.85 (lag) and 0.95 (lead)
  - Start-up tests of the Plant equipment, facilities and
  - Verification of vibration and noise emission
  - Environmental monitoring equipment, water quality monitoring equipment, functioning tests and verification of guarantees
  - Verification of active power response and voltage control response according to the requirements specified in the network connection conditions
  - Demonstration of proper controlling, monitoring and recording according to the requirements of the grid code shall be as per MPP recommendations.
  - Verification of completeness of scope of supply. This shall be carried out along with the punch list.
  - Verification of 24 hours uninterrupted MCR operation
  - Establish the capability to deliver the specified process steam even at minimum Gas turbine load, without any fresh air for atleast 8 hours on a continuous basis.


#### 9.4.0 Trial Operations

After successful completion of commissioning test and after relevant test protocols have been accepted by the Owner /Owner's representative, the Contractor shall be allowed to prepare the Plant Units for trial operation. The plant will be started up and loaded. During this loading operation all the controls and protections shall be finally set.

After the plant is loaded to the maximum capability rating and the contractor is fully satisfied with its performance he shall offer the unit for Trial Operation by communicating the same to the Owner/Owner's representative in writing. After receipt of such communication the plant will be on trial operation. The trial operation will be for a minimum period of fifteen (15) days continuously at rated full load/part load as made available by the Owner/Owner's representative or as mutually agreed between the contractor & / Owner/Owner's representative to demonstrate the following :-

- Sustained capability of the plant
- Reliability of the equipment and auxiliaries
- Adequacy of the various auxiliaries, ancillaries & systems and controls.
- Capability of each equipment of the plant to correctly perform the functions for which it is specified.
- Safety requirements

This trial operation shall be undertaken jointly with the Owner/Owner's representative. As a part of the trial operation reliability run and guarantee tests of the plant shall be conducted.

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**9.5.0 Reliability Run**

Reliability run shall be undertaken jointly with the Owner/Owner's representative as a part of the trial operation and within the trial operation period. Reliability run shall be conducted for seven (7) days uninterrupted at a load as available at prevailing ambient conditions.

In the event of interruptions to the reliability test run, for which the Contractor is responsible, the length of the reliability test run can be extended by a period equal to the total duration of the interruptions. If such an interruption lasts more than 24 hours, the reliability test run shall be restarted, after repairing the defect. The reliability test run may be interrupted on a maximum of three occasions, provided that no interruption exceeds 8 hours and that the Owner/Owner's representative is notified of the interruption in good time.

After the successful completion of reliability run test the Contractor shall offer the Owner/Owner's representative to conduct the guarantee test on prior intimation to the Owner/Owner's representative. The Contractor shall conduct guarantee test as per approved procedures for such test to the satisfaction of the Owner/Owner's representative. Performance and guarantee tests shall be a part of the trial operation and shall be conducted to the requirements of testing stated under the clause Guarantee test.

Essentially the performance tests shall consist of a simultaneous test to establish the capability of the plant when delivering the base load. The gross heat rate of the unit shall be also tested while demonstrating to the Owner/Owner's representative the Gross Power Output and Auxiliary Power Consumption in order to demonstrate that the plant is able to perform within the parameter limits specified in clause 20 below.

A joint log would be maintained to note various performance data, the malfunctions, output deficiency and short comings and would be compiled and furnished at the end of the trial operation along with the performance test results.

**9.6.0 Guarantee Test**

This consists of performance and guarantee tests as a part of the trial operation and within the trial operation period.

**9.6.1 Objective of the test**

The parameters which have an impact on commercial viability of the station are Gross Power Output & Gross Heat rate of the plant and the Auxiliary Power Consumption for the entire plant.


Performance Guarantee shall be provided for operation at contract specific site reference conditions as specified and the guaranteed performance parameters of the plant shall be proved by the Contractor during the test. Should the results of these tests show any deficiency from the guaranteed value, the Contractor shall modify the equipment as required at no extra cost to enable it to meet the guaranteed parameters.

All heat rates shall be based on Lower Heating value for the fuel.

**9.6.2 Test Documents**

The procedure for carrying out the above tests shall be submitted to the Owner/Owner's representative for approval six (6) months in advance. The procedure shall highlight the anticipated date for the test, arrangement and form of the tests.

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The procedure shall include the following for each test or group of tests:

1. The sequence of the tests to be conducted.
2. The time duration of each test
3. The number of test runs
4. A list of instruments that will be used for each test. The list shall define which instruments are (a) special test instruments, (b) certified, (c) to be calibrated before and after each test, (d) check instruments, (e) station supply instruments (f) Schematic diagram showing all test points and cross referenced to the instrument list and (g) method of data logging. Data logging thro' satellite communication is not permitted.
5. All formulae, calculations, conversion factors, curves, correction curves etc., to be used in the conducting of the tests and the calculations of the test results. All such items shall be to a accuracy level of four decimals.
6. Sample test reports to data sheets and all specific result sheet forms that will be used for the test.
7. Written procedure and description of conducting the test.

**9.6.3 Testing Method**

The testing shall be carried out as per PTC – 46. The test boundary shall include the entire unit with heat sink.

**9.6.3.1 Measurements**

The following measurement has to be taken during performance and guarantee test

**Output**

- ♦ Gross power out put of the GTG and STG
  - ♦ Auxiliary Power Consumption
- ♦ Noise level


All the plant, equipment and systems covered under this specification shall perform continuously without exceeding the noise level over the entire range of output and operating frequency.

Noise level measurement shall be carried out using applicable and internationally acceptable standards. The measurement shall be carried out with a calibrated integrated sound level meter meeting the requirement of IEC 651 or BS 5969 or IS 9779.

Sound pressure shall be measured all around the equipment at a distance of 1.0 m horizontally from the nearest surface of any equipment/machine and at a height of 1.5 m above the floor level in elevation.

A minimum of 6 points around each equipment shall be covered for measurement. Additional measurement points shall be considered based on the applicable standards and the size of the equipment. The measurement shall be done with slow response on

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the A-weighting scale. The average of A-weighted sound pressure level measurements expressed in decibels to a reference of 0.0002 micro bar shall not exceed 85 dBA.

Corrections for background noise shall be considered in line with the applicable standards. All the necessary data for determining these corrections in line with the applicable standards shall be collected during the tests.

- ♦ Emission level

**Input**

- ♦ Natural Gas consumption

**Specific Site Conditions**

- Ambient pressure
- Ambient temperature
- Relative humidity
- Grid frequency
- Power factor
- Fuel analysis (Natural Gas)
- Cycle blow down

Correction curves shall be applied only on the above measured specific site conditions to arrive at the Plant Performance Parameters at the contract specified specific site reference conditions.

**9.6.3.2 Contract Specific Site Reference Conditions**

- ♦ Ambient pressure - 1013 mbar
- ♦ Ambient temperature- 35°C
- ♦ Relative humidity - 70 %
- ♦ Grid frequency - 50 Hz
- ♦ Power factor – 0.80
- ♦ Design NOX – As per GPCB norms
- ♦ Design fuel analysis - LHV of the Natural gas fuel as per contract
- ♦ Cycle blow down equal to 0 %
- ♦ Deterioration due to aging - factors that are to be applied for Gross power output as agreed and stated in the contract.
- ♦ Tolerances that are to be applied on corrected Gross Heat Rate and Gross power output parameters as specifically stated in the contract.


**9.6.3.3 Specific Conditions of Testing Method**

The correction method stated under cl.5.5.2 in PTC 46 shall be applied to correct the performance parameters measured and corrected as per the above stated method Tolerances are applied over these corrected performance parameters in such case.

**9.6.3.4 Test Uncertainties**

The test uncertainty (not tolerance) shall be calculated based on the accuracy and number of test instruments utilized. The same shall be done as per PTC 46 and the maximum expected uncertainty shall not exceed 3 % for corrected gross heat rate and 1.2% for corrected Gross

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power output to validate the test. Accordingly the Tenderer shall state in the proposal the permitted deviations/fluctuations of design parameters that are permitted during the test for each operating mode testing.

**9.6.3.5 Correction Curves & Tolerance**

The correction curves shall be provided as mathematical equations in addition to the curves to an accuracy of four decimals. The equations supplied shall be utilized to perform the test result calculations.

**9.6.4 Measuring Equipment**

All test instrumentation and test equipment shall be provided by the Contractor. All the instruments shall be calibrated by a certified body before and after the tests. The calibration certificates shall be submitted to the Owner/Owner's representative prior to the tests. The calibration certificates shall be considered valid for a period of not more than six (6) months from the date of its calibration.

The anticipated points of measurement together with necessary isolation during the tests shall be indicated by the Contractor.

**10.0.0 CLEANING, PROTECTIVE COATING AND PAINTING**

Refer Vol III /Section 2/ Sub Section 2.15 Surface Preparation and Painting.

**11.0.0 SPARE PARTS**

The contractor shall also provide a list of recommended spares for two (2) years of normal operation of the plant over and above the mandatory spares.

**11.1.0 List of Mandatory Spares**

Refer Vol IV /Section 8/ Annexure 2

NOTE: All mandatory spares as per OEM declared critical items shall be included in the list.


**12.0.0 SPECIAL TOOLS, TACKLES AND EQUIPMENT**

One set of special tools and tackles required unit for the operation, maintenance, inspection and repair of the individual main equipment and auxiliary equipment shall be supplied by the Contractors in sufficient quantity to equip the shift personnel, maintenance personnel and workshop craftsman for commissioning, testing, calibration, modification and maintenance of the unit, List of such special tools, tackles and equipment shall be submitted in the EPC bid. Special tools and tackles excludes conventional ones and those locally available normally (not those requiring a drawing and considered as those made to order).

The special tools and equipment for maintenance and repair shall be delivered by the Contractor in lockable steel boxes and they shall be marked in an approved manner for identification purposes and a corresponding tool chart shall be supplied with the steel boxes.

The following tools and appliances shall be supplied under this Contract for use by the Owner/Owner's representative:

- two sets of special tools and gauges required for the maintenance of the Plant
- one set of special lifting and handling tackles / appliances required for the maintenance of the Plant.

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The tools, tackles and appliances supplied in general, shall not be used for erection purposes by the Contractor and shall be handed over in brand new condition. Damaged tools, tackles, and appliances shall be replaced before handing over.

The exception to this is the special lifting gear which may be used provided that when it is handed over to the Owner/Owner's representative it has not been subjected to more than normal wear and is still fully suitable for its intended use.

Each set of tools, gauges and appliances under category (a) above shall be suitably arranged in fitted boxes of mild steel construction, the number of boxes being determined in relation to the layout of the plant and equipment in question.

If the weight of any box and its contents should be such that it cannot conveniently be carried, it shall be supported on steerable rubber-tyred wheels.

Each cabinet and box shall be painted, fitted with a lock and clearly marked in white letters with the name of the item of equipment for which the tools and appliances contained are intended.

Suitable storage racks shall be provided for all portable lifting tackle supplied under this contract.

Suitable lifting lugs, ears or ring bolts, or tapped holes for lifting rings shall be provided on all equipment items where the weight exceeds 15 kg.

All lifting tackle shall be stamped with a unique identification number and safe working load. A test certificate from an approved Authority shall be supplied for each item of lifting tackle.

The Contractor shall provide a schedule of all lifting tackle and tools and appliances being supplied, for the approval of the Owner/Owner's representative.

The Contractor shall provide all runway beams, trolleys, lifting blocks, special slings necessary for the safe and efficient handling and maintenance of the works. Particular attention shall be paid to handling of equipment located at higher elevations safety valves

The tools and appliances with the appropriate storage racks, cabinets and boxes shall be handed over to the Owner/Owner's representative at the time of Taking Over of the complete Plant.

Since the Contract includes site erection, any special tools or appliances required solely for erection shall be provided by the Contractor for his own use and shall remain the property of the Contractor.

Control and Instrumentation: Software with associated hardware required to access instruments or control systems to be provided.


**13.0.0 CONSUMABLES**

**13.1.0 Lubricants and greases**

All lubricants proposed for the Plant operation shall be suitable for all operating and environmental conditions that will be met on site.

All oils and greases shall where possible be readily available in India.

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The number of oils and greases shall be kept to a minimum to the extent feasible. For each type and grade of lubricant recommended the contractor shall list at least three equivalent lubricants manufactured by alternative companies. This will be in line with that suggested by OEM and outcome will be informed to the Owner/Owner's representative.

In case of imported oils, lubricants and other consumables, the contractor shall indicate the indigenous equivalents to enable the Owner/Owner's representative to arrange subsequent fills. Preference should be given to indigenous oils and lubricants during first filling itself. Short shelf life items if any may be supplied in a phased manner keeping in view of their actual use.

The Contractor shall supply the first fill lubricants and greases, and also shall provide at the Completion Certificate sufficient lubricants and greases necessary for the efficient operation and maintenance of the Plant at full load 24 hours per day for a period as mentioned in the relevant portion of Commercial Specification.

**13.2.0 Chemicals and other consumables**

Contract includes the supply (by the Contractor) of all chemicals, reagents, resins, and other consumables required for testing, commissioning and setting to work of each section of the Works.

The Contractor shall provide all chemicals and other consumables required for the efficient operation and maintenance of the plant at full load 24 hours per day for a period as mentioned in the relevant portion of Commercial Specification.

The Contractor shall prepare a list of these consumables giving quantities necessary for each section of the works and the recommended suppliers.

The Contractor shall deliver to site sufficient quantities of consumables in his supply to allow for 6 months running of the Works prior to the issue of the Completion Certificate. The delivery of the remainder of the consumables shall be programmed to suit the operational requirements and space availability within the various stores.

**14.0.0 DOCUMENTATION**

**14.1.0 Format of Documentation**

All engineering documents and drawings shall be of international "A" series sizes, that is, A0, A1, A2, A3 and A4.

One set of CD containing all the drawings in Auto CAD (for final as built drawings) shall also be supplied in addition to hard copies.

Soft copy of all other documents shall be supplied in a CD in PDF or editable format. For review purpose pdf or editable version shall be considered.


Grouped documents shall be provided by size A4, with the inclusion of bigger size drawings which, however, have to be folded as Size A4.

For MPP package documentation shall be as per MPP standard.

**14.2.0 Numbering and Identification of Documents**

All the drawings shall be identified through a common way of numbering in accordance with the requirement of contracting. The numbering system of drawings and documents proposed by the Contractor shall be in compliance with the plant identification system and to be agreed

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with the Owner/Owner's representative. Apart from this, some drawings may also be numbered in the way which the contractor or subcontractors are used to do. But, there shall be a common title Block on all published drawings which include the following contents:

- Owner
- Owner's Engineer
- Project
- Contractor
- System
- Drawing No.
- Sheet No
- Revision No.

The measuring units and dimensions marked on the project engineering drawings shall be of SI system conforming to ISO 1000.

English words shall be used as descriptions on drawings.

In case dimensions are not marked in conformity with the scale of drawings and any dimension on the drawing does not conform to those dimensions and sizes measured through certain scale, the actual marked dimensions shall be applicable.

For revision of drawings, the revised part shall be clearly and definitely shown on the drawing. For revision of documents which have been grouped together, a brief description shall be a perpendicular line with the margin of the revised copy closely following it.

#### 14.3.0 Provision for Documents

Generally, copies of drawings or documents containing trade secret and drawings with patented nature need not be provided.


However, to know whether the Contractor has performed its obligations, the Owner/Owner's representative has the right to examine those drawings within the Contractor's working scope.

The Contractor shall meet the Owner/Owner's representative's reasonable demands to files and do the following to satisfy the Owner/Owner's representative:

- Contractor will work according to the requirements specified in the contract.
- Contractor's working has been arranged properly and developed according to the plan.
- The quality control system is reliable.
- After receiving all documents necessary for power plant operation and maintenance, Contractor shall supply equipment and systems.
- Having received all necessary documents for Contractor to perform its legal obligations or other relevant responsibilities.

#### 14.4.0 Owner/Owner's representative's Responsibilities

The Owner/Owner's representative agrees that the Contract will be concluded in accordance with the EPC method of building the power plant. It is the Contractor's duty to ensure that design standards and conditions meet the requirements and that the power plant shall operate safely and reliably and with high efficiency, having the same performance as

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stipulated and guaranteed. This is applicable until the plant performance is established in the last PG test. The plant performance beyond such last PG test will not be the same because of degradation as per equipment characteristics.

The Owner/Owner's representative will examine and check the drawings and documents with the aim of ensuring all these drawings and documents meet the demands and duties written in the documents. The Contractor shall have an active and cooperation working relationship with the Owner/Owner's representative.

If drawings and documents have been supplied to the Owner/Owner's representative, Contractor will await clearance / approval from Owner/Owner's representative at a pre-agreed time frame, before proceeding on design. In case, Owner/Owner's representative has comments / opinion, the same can be informed to the Contractor on priority basis so that corrections, if feasible could be incorporated in the drawings.

**15.0.0 PLANT AND EQUIPMENT IDENTIFICATION, LABELLING**

**15.1.0 Plant and Equipment Identification**

The contractor shall follow identification system for the whole plant equipment, instruments, facilities and systems as per the Annexure-4 Guide for Coding Equipment, Documents & Drawings

MPP generated drawings, identification system shall be based on MPP standard.

**15.2.0 Labelling**

Name plates which are to be firmly fixed on all the equipment, instruments, buildings and structures shall be provided. For equipment of small size, these are to be fixed on the piping or structure adjacent to the equipment. The contents of nameplate are to include the designation and principal parameters of the equipment.

The nameplate within the field shall be made of a high temperature - resistant metallic sheets, with designation permanently engraved on them. Indoor installed equipments (e.g., panels, cabinets, switchgear) shall also be labelled by appropriate name plate.


The form, size, base colour and colour of contents of the name plates and prompting plates will be agreed between the Contractor and the Owner/Owner's representative. It shall be possible for these to be readily seen by the operator. The designation of warning tags shall be different from that of other tags. All buried pipes and cables routes shall be identified with permanent marker.

**16.0.0 CONTRACT DRAWINGS, DOCUMENTS FOR APPROVAL, LIAISON MEETINGS**

**16.1.0 General**

The Owner/Owner's representative reserves the right to ask the Contractor to submit copies of drawings and other documents for approval to his Head Office or to the Office of his Representatives. If the Owner/Owner's representative or his Representatives are satisfied with the drawing, one copy will be returned to the Contractor marked with an 'Approved' stamp Within a pre-agreed time frame, If the Owner/Owner's representative or his Representatives are not satisfied with the drawing, one copy stamped 'Examined and Returned with Comments' will be returned to the Contractor with comments marked thereon and the drawing shall be revised and re-submitted for approval.

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The purpose of having drawings checked and approved by the Owner/Owner's representative is to assist the Contractor in interpreting the Technical Specification so as to eliminate mistakes in the equipment or material actually shipped to the site of the work. The formal approval given to the Contractor is to be considered as in conformity with this purpose and in no manner shall be construed so as to release the Contractor from any liability or responsibility for proper design, fabrication or compliance with the Contract Documents.

Equipment drawings shall clearly indicate the general arrangement of the equipment to be furnished, give principal dimensions, and show sufficient details required for a complete power station.

While submitting drawings for approval, including any prepared by a Sub-Contractor, the Contractor shall certify that he has fully examined such drawings and that they comply with the requirements of the Contract.

If any item, equipment or work shown in the drawings does not completely comply with the requirements of the Specification or any other requirement of the Contract Document, the Contractor is obliged to clearly inform the Owner/Owner's representative and his Representatives of the differences giving full explanations and reasons for such changes.

For the purpose of this Clause, the term "drawing" shall include design calculations, equipment specifications, diagrams, schedules, performance curves.

Approval of a drawing by the Owner/Owner's representative will imply that:

- a) Arrangement and layout drawings and key diagrams have been examined and appear to be in accordance with the basic design concept of the project and meet the requirements of the Specification.
- b) Other drawings of components and equipment have only been examined in relation to compatibility of the items and equipment with the Specification and in respect of interconnection with other items and equipment.
- c) Any approval given by the Owner/Owner's representative shall in no way relieve the Contractor of his responsibility under the Contract.


The Owner/Owner's representative will not normally require to receive copies of detailed manufacturing drawings but the Contractor shall make these available if requested to do so.

The Contractor shall ensure that drawings are submitted in due time to permit amendments to be made and the drawings re-submitted for approval without delaying the scheduled deliveries or the guaranteed completion dates according to the Contract. Execution of work shall be taken up after the drawings are cleared by the Owner/Owner's representative.

If, during the Contract period, the Contractor is required to modify the size of any buildings, foundation from that shown in Technical Specification drawings to accommodate the finally approved arrangement of the Work (with due allowance for access, laydown, maintenance), then such modification shall be deemed to be included in the scope of the EPC Contract.

Requirements about the format of drawings and documents, the provision for documents and the Owner/Owner's representative's responsibilities with regard to documentation are specified in relevant section of this volume.

The Contractor shall be responsible for any discrepancies, errors or omissions in the drawings and other particulars supplied by him, whether such drawings and particulars have been approved by the Owner/Owner's representative or not.

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**16.2.0 Documentation by Contractor**

The drawings to be submitted by the Contractor for approval shall cover the complete Scope of Contract work as defined by the Contract Specification and shall generally include, but not be limited to, the following:

**16.2.1 Drawings and Documents to be submitted along with the proposal**

**(A) General (applicable for all discipline)**

- Heat and Mass balance diagram as specified in Vol IV /Section 7 (Technical Data sheets and Schedules to be filled in by the Bidder).
- Completely filled in technical schedules for all equipments as enclosed with the Tender specification.
- P&ID (Process and Instrumentation drawings) indicating Instruments and the destination / functionality of the signals.
- Plot Plan.
- List of spares
- List of Special tools and Tackles

**(B) Mechanical**

Start up curve for cold, warm and hot condition


Performance and correction curve for Gas Turbine, Steam Turbine and HRSG

**(C) Electrical**

- Key Single line diagram
- Metering and protection Single line diagram for Generators
- Metering & protection Single line diagram for 66kV GIS
- Single line diagram for Auxiliary power distribution
- Description of all Electrical equipment
- Generator capability curve, Voltage vs frequency curve, Overload capability curve , Open and short circuit characteristic and Excitation curves

**(D) Control and Instrumentation**

- Control system configuration / architecture drawing for Plant DCS, GT & Generator, ST, local PLC's.
- Control philosophy / operation philosophy / design philosophy / redundancy philosophy.
- Scope of supply and services for C&I.
- Brief process description / functional write – up for all open loop and closed loop controls.
- Details of C&I and PLC System offered for offsite plants.
- Brief write-up, scheme, technical details of Continuous Emission Monitoring (CEM), Steam and Water Analysis System (SWAS) .
- Codes and applicable standards followed for the project.
- List of vendors for instrument / equipment.

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- Deviation schedule (if any)

**16.2.2 Drawings and Documents to be submitted after Award of Contract**


The documents required for design, construction, installation, operation and maintenance of the entire plant shall be submitted by the Contractor in good time so as to permit the plant as a whole to be constructed in compliance with the specified time table. The Contractor shall establish a online document and work flow management system to control the document flow and the approval process.

MPP supplied equipment will follow their standard documentation.

Only the most important documents are listed below. The list and approval category of the doc/drawings shall be agreed sufficiently in advance before award of relevant order, so that corrections and amendments desired by the Owner/Owner's representative as well as resubmission of the documents will not result in any delays with respect to the guaranteed time table. The Owner/Owner's representative reserves the right to request from the Contractor additional drawings, documents as may be required for proper understanding and definition of the design and engineering of the Plant.

**(A) General**

- Re-Submission of all the technical data furnished during pre award contract stage.
- Complete filled-in technical schedule.- For approval
- Plot plan - For approval
- General arrangement drawings /Equipment layout of all equipments along with sections indicating the unloading and maintenance area .- For approval
- Design basis for all the systems and major equipment sizing calculation - For approval
- P&ID (Process and Instrumentation drawings) indicating Instruments and the interlocks for all the systems - For approval
- Monthly progress report with photographs (Hard and soft copies)
- L2 network
- Quality plan for approval
- Equipment Testing procedure for approval
- Complete list of documents with proposed submission schedule
- Vendor Engineering document via Data sheets, General arrangement drawing , material of construction ,performance curves for approval for major items
- Painting and surface preparation procedure
- Technical specification
- General arrangement drawing with section for major building viz., GTG/STG hall, CW pump house, Deaerator & BFP area 66 KV switch yard,66 KV indoor GIS room and HRSG showing maintenance area
- Description of options and alternatives offered
- Safety Plan
- Training program and schedule for training of Owner/Owner's representative's personnel
- Space requirement for construction site and equipment
- Maintenance proposal (for GTG, STG and Fuel Gas system)
- Inspection intervals (major/minor)for six years along with the spares to be replaced during the above inspections .

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- Bidder shall enter into a long term spare supply agreement with the OEM and agree to transfer the same faithfully to the Owner/Owner's representative upon COD. Bidder shall commit to facilitate further negotiations on the spares with the OEMs directly by the Owner/Owner's representative.

**(B) Mechanical**

- Major equipment sizing calculation viz Boiler Feed pump, Condensate extraction pump, Condenser cooling water pump, Aux cooling and closed cooling water pump, Air compressor, Bypass valve, Make-up pumps, for approval
- Start-up and shut down procedure along with the curve for approval
- Content (index) of the system description document for approval
- System description for all the systems for approval
- Pipe rack and composite piping layout for approval
- Thermal calculation for critical items for approval
- Fire protection system layout
- Heating and ventilation system layout
- Pipe sizing and determination of pressure and Temperature criteria. for approval
- Critical piping drg and calculation
- Acceptance and Performance test procedure and program
- Acid/Alkali/Boiling out procedures

**(C) Electrical**


- Key Single line diagram
- Single line diagram for Auxiliary power distribution for approval
- Single line diagram of Switchboards
- Single line diagram for switchgears
- Metering and protection Single Line diagram
- Logic diagram and schematic diagram
- Wiring diagrams of all equipment
- Performance / Characteristic curves of Generators, Motors, transformers.
- System Study such as Load flow, Short circuit, Motor starting calculations.(to be done in ETAP and ETAP file to be submitted for review)
- 66kV GIS metering & protection SLD, Schemes & General arrangement
- 66kV transmission conductor data sheet other details
- 66kV OHL sag tension calculation
- SAS architecture & system description
- SAS input & output list
- Electrical equipment layout.
- Lighting layout, earthing and lightning protection layout.
- Notes & details for lighting, cable tray, lightning, earthing.
- Foundation details, fixing details and loading details of all equipments.
- Installation details
- Cable tray/routing layouts for the entire plant
- Cable block diagrams ,Cable schedule and interconnection schedule

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- Relay setting calculations (to be done in ETAP and ETAP file to be submitted for review)
- CT and VT sizing calculations
- Electrical load list / equipment list
- Alarm schedule and list of Circuit breakers and control.
- GA drawing for all the major equipment such as Generators, transformers, Busducts, Description Excitation System and AVR.
- Type test certificates for Generator, Generator transformer.
- Catalogues of all electrical equipment.
- GA drawing for all the major equipment such as generators, transformers, busducts, description excitation system and AVR.
- Type test certifications for generator, generator transformer.

**(D) Control and Instrumentation**


- Detail dimensional drawings of various equipment, components / sub-assemblies.
- Control Room layouts
- Detailed DCS / PLC/ GT & Generator, ST control system architecture drawing (also indicating interconnection of different offsite C&I System) highlighting the applicable standards for control and information domain ; networking and security features; graphic capabilities data exchanger procedure, engineering tool, system capability such as graphic displays, trending, archiving, logs, reports.
- Outline general arrangement / Internal general arrangement drawing for all the I&C equipments drawing for all the I&C equipments.
- DCS / PLC / Local control system / Vibration monitoring system functional specification covering both the hardware and software details along with the data sheets and technical catalogues.
- DCS / PLC IO allocation details, System loading details, controller grouping details.
- Design philosophy of C&I systems.
- Process description / functional write – up for all open loop and closed loop controls
- Instrument loop schematics,
- Analog control schemes, Logic and protection diagrams for the entire I&C system along with the write-up/functional description.
- Performance calculations write up.
- Start-up and shutdown logics with procedures and write-ups
- Grouping philosophy of control loops in controllers.
- Marshalling / cabling philosophy
- Cable schedule, JB Scheudle ,Interconnection and wiring schematics for the I&C systems offered.
- Detail wiring diagrams of all panel desk, control consoles, system cabinets.
- Plant graphics, alarms, various displays, logs and reports with menu and format.
- Flow element sizing calculations and dimensional drawings.
- Control valve and Safety Relief Valve sizing calculations and dimensional drawings.
- Operation and maintenance manuals for all the I&C equipments and systems.
- Details of the PLC / C&I System in offsite plants.
- Interconnection Diagram of different PLCs and the DCS showing all hardware details.
- Analog and binary drive list for the entire system

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- Complete Instrument Schedule, DCS I/O list, (Software and hardware) Annunciation list, SOE list, Hardware list for safe shut down, Flow element schedule, Control valve schedule, JB schedule, Rack schedule.
- Data sheets, Specifications, Technical manuals and catalogues for the offered make and model of field instruments, analyzers, lab instruments, SWAS system, SEMS, GPS, CCTV, erection hardware and associated accessories.
- Technical Particular Sheets of each hardware / instrument/control system/software offered with complete bill of materials and related detailed technical literature, coding procedure.
- Confirmation certificate for the latest version of software and hardware offered.
- Final BOQ for the I&C system with the bought item vendor list.
- Calibration test and quality assurance test procedure and test certificates.
- Pre-FAT, FAT(Factory Acceptance Test), SAT (Site Acceptance Test) reports
- Instrument installation and Hook-up diagrams showing all erection hardwares.
- Tapping point details.
- Instrumentation Layouts such as, CEM room layout, SWAS room layout, JB/ Rack/ Tray /Instrument location drawing.
- C&I power distribution scheme including UPS supply.
- Instrument air distribution scheme.
- Reference list with capacity of plant, year of commissioning and control system implemented along with minimum two users' certificate for the DCS system configuration offered.
- Evidence that the offered DCS system is upgradable and evolutionary in both hardware and software
- Letter confirming that any future compliance required for the system / applications software supplied and all up gradation would be implemented.
- Spare parts list, Laboratory Instrument list, test and calibration report, special tools and tackle list.
- Earthing schemes,
- All other lists and drawings as required
- DCS vendor drawings/documents.
- All the above drawings as applicable for the mechanical packages

**(E) Civil**

- General site plan of the entire site showing all buildings and installations, traffic routes and landscaping.
- Architectural arrangement drawings, design layouts and itemized drawings (plans, elevations and sections) to scale 1:100 of all buildings and plants
- Views of all sides of all buildings, scale 1:100
- Architectural drawings of each floor (plans, sections) including all necessary detail drawings, scale 1:50
- Arrangement drawings of the external plants of the site as a whole (existing, planned) with all supply and disposal facilities, roads and vehicle access and manoeuvring areas, sewers, channels and culverts.
- Detailed constructive description of the building with regard to the structural design (structural systems, foundations)

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- Detailed specification of the buildings including information on interior decoration ,materials and qualities for execution
- Detailed construction drawings of all corresponding civil / structural / Architectural works including buildings, foundations, roads, trenches, cable ducts and services.
- Structural design calculations for all buildings and foundations including equipment foundation. For rotating and vibratory equipment, dynamic analysis calculations shall also be submitted. Relevant software files used for analysis and design shall also to be submitted.
- Sectional elevations and roof plan
- False floors/systems
- Underground services and ducts with equipment appertaining to the services
- Layout of roads
- Plant drains layout
- Design of Roads and Drains.
- Principal details and sections for traffic areas, especially for ramps and retaining walls
- Layouts for external works showing plants and fencing.
- Schematic details for plumbing
- Foundations and other underground concrete works for the transformer area.
- Finishing schedules for all the buildings.

**(F) Others**


- Testing report for approval.
- Declaration of conformance with statutory regulations.
- Operation and Maintenance manual.
- Training program.
- As-built-documentation including drawings of all equipment
- Complete bill of materials of the plant with expected life of major items along with break up price.
- Welding procedure (for workshop and site).
- Lubrication list and Schedule.
- Site Quality plan.
- Erection and Commissioning procedure.
- Overall project implementation with key dates and milestones for major plants design, construction, erection, test run, mechanical completion / pre-commissioning testing / commissioning, trial operation / Reliability run test / performance guarantee test run, and taking over of the complete power plant.
- Reference lists for delivery and installation of plants of similar type and size.
- Layout of temporary site facilities , buildings, structures , installations.

**16.3.0 Liaison Meetings**

The liaison meetings shall be organised by the contractor. Time period for the same shall be mutually discussed and agreed after contract finalization stage. Document distribution schedule shall be discussed and finalized after contract award stage.

Contractor shall supply all documents required in the appropriated number as requested by the Owner/Owner's representative.

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**16.4.0 Distribution of documents**


The source, distribution, no. of copies shall be as per the following document distribution schedule.



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16.4.1 Document Distribution Schedule - After Placement of Order

Sl. No.	Document	Total	Distribution		Owner's representative
			Copies		
			HQ	SITE	
1.	PERT Network, work schedules, Bar charts, Layout drawings	10	-	5	5
2.	Data, drawings, documents, write-ups, calculation - Preliminary - Revised	10 10	- -	5 5	5 5
3.	Approved drawings and documents.	10	-	5	5
4.	Instruction manuals for erection and O&M	10	-	8	2
5.	As built drawings including O & M manual - Hard Copy - Soft Copy	10 -	- -	8 -	2 -

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**16.5.0 Manuals**

**General**

The Contractor shall provide the manuals in a timely manner to enable the Owner/Owner's representative to review and comments and request changes as necessary.

Payments will be withheld for non-compliance or for late delivery of the drawings, procedures and manuals. In particular the Contractor shall be held responsible for consequential damage to the plant where such damage is due to late delivery of the O&M manual resulting in non-familiarity of the operating technique.

The Contractor shall also note that while all documents, procedures and manuals shall be in the English language including that of the Subcontractor of the Contractor, it is particularly important that the O&M manuals be in clear concise English.

All manuals shall be divided by systems or sections and cross-indexed as necessary.

**Certification Manual**

This manual shall contain the approved works certification documentation for all plant equipment and services as specified in the relevant codes and standards and in this specification and the Contractors Quality Manual. This manual shall also include all material tests certificates. Certificates and test procedures shall be specific to the plant supplied.

**Design Manual**

This manual shall contain all the design calculations (except for HRSG) and all equipment and system data sheets and design criteria required under the Contract. Contractor shall provide a design basis report and HRSG datasheet during detailed engineering stage after award of Contract

**Construction Manual**

This shall include a comprehensive record of as built site construction tests and records. Again the manual(s) shall be compiled in separate parts to reflect the plant and services supplied.


**Commissioning Manual**

This manual shall include all the records, certificates and test results arising from the agreed pre-commissioning and commissioning procedures carried out on site. The performance tests and guarantee test results shall also be included. There is a particular requirement that all commissioned plant/equipment values be recorded in this manual and subsequently incorporated into the O&M manuals.

**Operating and Maintenance (O&M) Manuals**

The Contractor shall provide the O&M Manual properly bound, within the time specified, to enable the Owner/Owner's representative's staff to become fully acquainted with the operation, adjustment and maintenance of the entire plant. The manuals shall contain full and explicit instructions in respect of the operation of the plant under all operating conditions and the maintenance routines and requirements to be established to maintain the plant in optimum performance. These instructions shall be in the English language and be as comprehensive as possible and the form in which they are to be set out shall be agreed with the Owner/Owner's representative. The instructions may be divided as appropriate into individual sections and sub-sections as necessary. All section and sub-sections shall be clearly indexed and cross-referenced as required for clarity.

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The instructions shall be tailored to suit the specific requirements of the Operations and Maintenance functions and personnel, taking into account the staffing philosophy for the combined cycle power plants.

The instructions for the related parts shall be accurate and easy to understand and shall contain the necessary sequence of individual activities. The diagram and drawings associated with the instruction shall be clear and unambiguous.

It is an essential requirement that all information and plant data contained in the manual must be project specific and derived from the design, manufacturers / suppliers and commissioning data of the as-built plant. Where the Contractor includes standard brochures the installed item of plant or equipment shall be clearly identified. All sections shall contain an introductory description of the particular item/system including its function and operating criteria and any special features. On the basis of the commissioning and running experience of the Plant, the instructions shall be amended to a final form within three months of the end of commissioning and, for this purpose; the Contractor shall supply the required number of printed copies of all approved amendments for insertion in the bound set of instructions.

The entire O&M manuals including that of the Subcontractor shall all adopt the same format paper size. The Contractor shall prepare manuals integrating all equipments supplied by the Subcontractors.

**Operating Instructions:**

The instructions shall include at least the following specific procedures/practices /items:

- starting-up
- shutting down
- operation / procedures during fault conditions
- surveillance and monitoring of plant .check lists
- standard readings
- operational parameters (especially limiting values in critical areas)
- isolating procedures
- Earthing /switching
- trouble-shooting
- fault reporting
- normal operational reporting
- compliance with requirements for interfacing with grid.
- safety/security/fire fighting/ first aid
- general plant standards and guidelines .
- test procedures
- maintenance and operating management systems
- drawings, schematics, logics and wiring diagrams, function diagram, P&IDs.
- protection


**Maintenance Instructions:**

The instructions should provide for the three maintenance functional groups – 1) Mechanical, 2) Electrical, and 3) Control and Instrumentation - and shall include at least the following:

**Maintenance Management System**

- a complete and accurate description of the main plant items and systems of the Power Station specific to each function
- detailed maintenance procedures and intervals for all plant items.

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- assembly and disassembly procedures.
- spare parts
- use of special tools and equipment
- lifting procedures
- drawings, detailing tolerances
- schematics, logics and wiring diagrams, function diagrams P&ID's.
- isolating procedures,
- Safety and Codes of Safe Practice.
- Fire fighting/first aid
- set-up and calibrating procedures .
- optimisation of Control Loops
- diagnostics and trouble shooting
- specialist maintenance/repair procedures including welding procedures.
- materials test procedures

**Storage and Retrieval Facility**


For easy documentation storage and retrieval all the required software and hardware supply and commissioning shall be included in the scope of EPC Contractor.

**Owner/Owner's representative's Responsibilities**

The Owner/Owner's representative agrees that the Contract will be concluded in accordance with the EPC method of building the power plant. It is the Contractor's duty to ensure that design standards and conditions meet the requirements and that the power plant shall operate safely, reliably and with high efficiency, having the same performance as stipulated and guaranteed.

The Owner/Owner's representative may examine and check the drawings and documents at his discretion with the aim of ascertaining that all these drawings and documents meet the requirements specified in the contract documents. The Contractor shall have an active and cooperative working relationship with the Owner/Owner's representative. If there is a disagreement over any issue, Owner/Owner's representative and Contractor shall work together to reach some conclusion through mutual consultations.

The drawings and documents of the Contractor shall be returned with observations if any within ten working days by the Owner/Owner's representative. The Contractor shall clarify the observations raised by the Owner/Owner's representative and shall attempt to correct the drawing or document subsequently only.

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**17.0.0 ENVIRONMENTAL PROTECTION**

**17.1.0 Applicable Standards**

The project must conform to the national standards of the Republic of India. The following standards and /or regulations are to be applied:

**17.1.1 Environmental Quality Standards**

The discharge of pollution in water and air as well as noise levels shall meet with the stipulations of State Pollution Control Board as well as other Acts of the Government under the Ministry of Environment and Forestry. It is a pre-condition that irrespective of what is stated in statutory regulations or any other act or norms, the Specification stipulated environmental qualities standards are the minimum requirements and shall be fulfilled in all aspects.

**17.2.0 Fundamental Requirements of Environmental Protection for Power Plants**

**17.2.1 General Principals**

To protect the environment, Power Plant should comply with state regulations, carry out composition and review system for Environmental Impact Assessment (EIA) report and execute the "Three Simultaneousness" system, namely, simultaneous design as per Technical Specifications, construction and operation of both pollution prevention facilities and the main plant. The preparation of EIA is not a part of EPC Contractor's Scope.

Environmental protection design for the power plant shall be based on the requirements of CPCB/ SPCB and relevant stipulations, and state of the art, proven technology shall be adopted. Latest CPCB/ SPCB guidelines as applicable.

**17.2.2 Atmosphere Pollution Prevention and Control**


HRSG main stack height shall satisfy the State Pollution Control Board requirement. The height of the HRSG stack shall be finalised during detail engineering (DDE). The exit velocity of flue gas at stack shall not be less than 22 m/s.

**17.2.3 Water Pollution Prevention and Control**

The plant should be designed to economize on water use and to set up a water management system featuring equilibrium between water feed and water discharge.

- Waste water from the plant shall be treated in distributed mode and will reach the standards before it is discharged to the final discharge point, i.e measurement shall be carried out before the return water reaches the existing seal pit
- The acid and alkali waste water from the chemical treatment station will be discharged after being treated in the neutralization pit and reaching the standards.
- The sanitary sewage will be permitted to discharge after the sewage has internally been treated and met the required criteria.
- The cooling tower blowdown shall be routed to the nearest OWS drain pit before being finally treated in the existing OWS treatment system. Also provision shall be kept for routing the cooling tower blowdown to the storm water drain with an isolation valve.
- Boiler blowdown along with the oily waste water (intermittent) shall be routed to the nearest PWS drain pit before being finally treated in the existing PWS treatment system.

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**17.2.4 Noise Pollution Prevention and Control**

The Contractor shall take all necessary measures for noise attenuation in order to meet the specified noise levels.

General requirements of noise control :

- The minimum requirement shall be met as whatever has been specified in each of the Detailed Technical Specifications. However the station shall be acoustically designed so that an admissible noise level of 70 dB (A) during night time and 75 dB(A) during day time shall not exceed at nearest Property boundary during normal operating mode.

For Central Control room, near to the duct noise level shall not exceed 60 dB(A) and at other places noise levels shall not exceed 50 dB(A)

The noise level in the offices and the control room shall be not more than 50 dB (A)

The Contractor shall take measures for noise attenuation, if the above mentioned noise levels are not met.

**17.2.5 Flue Gas Emission Levels**

In order to meet the environmental quality requirements, the Contractor has to guarantee that at all loads and operating conditions of the plant the following flue gas emission levels, measured in the Main stack.

- Natural Gas – As per GPCB norms or better.

The above indicated emission levels shall be guaranteed by the Contractor for the entire load operation. Bidder to indicate how the Low NOx emission shall be ensured in the bid.

The Contractor shall provide on-line In-situ automatic continuous Stack Emission Monitoring System (SEMS) for monitoring the levels of SOx, NOx, SPM, CO, O<sub>2</sub>, flue gas temperature and exit velocity. The Contractor shall also provide portable kit for measuring SOx, NOx and SPM in stack. Monitoring of required signals to Pollution control board shall be through an operator station . Required software shall be provided by contractor.

**18.0.0 TRAINING REQUIREMENTS**


**18.1.0 General**

The Contractor shall be responsible for the instruction and training of the Owner/Owner's representative's operation and maintenance personnel in all aspects of plant design, construction, erection, commissioning. and in such a way that operation, maintenance and if necessary repairs of all the power plant equipment and facilities specified can be handled competently by the said personnel.

Such training of the Owner/Owner's representative's personnel shall be performed

- DCS training shall be provided at manufacturers place. All other training provided for balance of plant systems shall be class room training at site.
- In Contractor's and/or sub-suppliers'/manufacturers' home office and/or workshops;
- In similar plants and such plants which are in operation or on simulator;

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- On the job training at site by the Contractor's and/or his sub-suppliers, supervisors and/or instructors deputed to the site for supervision of erection, commissioning, testing and trial operation and/or by specialized training instructors.
- On the job training at site by the Contractor's and/or his sub-suppliers, supervisors and/or instructors deputed to the site for supervision of erection, commissioning, testing and trial operation and/or by specialized training instructors.
- At the Power Plant by the supervisors deputed to the Plant during the Warranty Period; in compliance with the provisions of the EPC Contract and the requirements of this specification.

The personnel required for the safe and efficient plant commercial operation and maintenance of the various types of equipment installed will be provided by the Owner/Owner's representative in accordance with the recommendation to be made by the Contractor.

The training shall be performed in English. Translators/interpreters if required shall be provided by the Contractor.

The Contractor's instructors shall use modern training techniques, procedures and aids and make available to the trainees all required notes, manuals, drawings to supplement the Operation and Maintenance Instruction Manuals.

The Contractor shall furnish during detail engineering detailed description on the recommended training services, including

- Number, category, seniority, experience required. of the personnel to be trained.
- Preliminary training program, showing
- Training facilities, training aids places of training
- Training schedule
- Specialty and details of lectures and training
- Duration of training courses

For each type of training such as classroom, manufacturer's / supplier/ sub-supplier works on the job site, at the proposed Plant.

The recommended training program should be based on the organizational and staff structures of similar plants already in operation in India, and should take into consideration not only the training for operation and maintenance staff, such as operators, skilled workers, foremen and technicians, but also for senior staff and key personnel employed for the management and organizational duties of the various power plant disciplines, such as for operation, maintenance, instrumentation and control, chemistry, administration, security, spare parts handling, scheduling and engineering.etc.


The bidder shall furnish in his bid quoted prices (all inclusive, taking into account the provisions specified in the following clause) for the training of the Owner/Owner's representative's personnel in the Contractor's country, in similar plants, at the Contractor's works and works of Contractor's sub-suppliers, on the job site and at the Plant site shall be given by the Bidder, based on his recommended training program to be indicated in the bid.

**18.2.0 Contractor's Obligations and Tasks**

The Contractor shall make every effort to train the Owner/Owner's representative's personnel so that they can be qualified for the management, operation and maintenance of the Plant.

The Contractor shall nominate their key person who will be in charge for organization and co-ordination of activities for training.

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The training program shall be carried out according to the requirements of each speciality. It shall include but not limited to the following:

- a) Systematic explanation in a classroom on specific subjects, such as the equipment performance, construction, main systems, auxiliary systems.
- b) Visit to similar plants.
- c) Practical training in similar power plants, which are under erection and commissioning.
- d) Practical training on simulators and control rooms of similar plants.
- b) Supply of all necessary training documentation (such as books, manuals, and drawings), equipment, tools and instruments. The Contractor will make best effort to achieve above item (c) and (d) with utility authority.

The Contractor will make available free of charge to the Owner/Owner's representative's personnel tools and tackles, safety helmets, shoes, stationary item as needed by the training program.

The Contractor shall allow the Owner/Owner's representative's personnel to carry back to India, all the technical documents supplied during the training. Transportation of Customer's personnel (air fare, car rental, train fare, etc.) to place of training will be to Owner/Owner's representative's account. Lodging and boarding and any other incidental expenses related to Training shall be to Owner/Owner's representative's account. Visa charges will be borne by Owner/Owner's representative. Local transportation from the place of staying to place of training shall be to Owner/Owner's representative's account.

The Contractor shall assist the Owner/Owner's representative's personnel in arranging entry visas and all the formalities for staying in foreign countries for training. Visa charges will be borne by Owner/Owner's representative. The Contractor shall also take all the necessary measures to ensure the safety of the Owner/Owner's representative's personnel during their stay in the foreign country.

Training shall be designed to offer instruction and training to both personnel with a reasonable level of experience in power plant operations and maintenance, and shall be of such quality so as to provide operation, maintenance personnel with a working understanding of all operational and maintenance aspects of the Plant. The purpose of the training services is to give to the Owner/Owner's representative's personnel a necessary knowledge of equipment and systems delivered by the Contractor.

In addition to classroom training, an essential part of the training will be the participation of the operation and maintenance personnel in the commissioning of the Plant.


Training shall be designed to offer instruction and training to personnel with a reasonable level of experience in power plant operations and maintenance, and shall be of such quality so as to provide operation, maintenance personnel with a working understanding of all operational and maintenance aspects of the Plant.

**18.3.0 Owner/Owner's representative's Responsibilities**

The Owner/Owner's representative shall appoint a person as official representative of the Owner/Owner's representative's trainees.

The trainees shall understand the English language and shall follow the training courses with due diligence. During their stay abroad, the Owner/Owner's representative's personnel shall

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observe the Laws of that country and the rules/regulations of the factories/plants where the training will be conducted. The official holidays or national holidays, and weekly holidays as per the plant/ project site shall be followed by the Owner/Owner's representative's personnel.

For the successful completion of the training program, unless mutually agreed by the parties, the program cannot be interrupted for vacation leave.

To and fro rail/road/airfare of trainees between the place of posting of the trainees and place of training shall be borne by the Owner/Owner's representative.

#### **18.4.0 Training schedule and program**

The program for the Owner/Owner's representative's personnel will be defined during the liaison meeting.

Two (2) months before the arrival of the first group of the Owner/Owner's representative's personnel in training site, the Owner/Owner's representative shall inform the Contractor of the date when the Owner/Owner's representative's personnel are expected to be sent to training site

Within 2 (two) weeks after receipt of the Owner/Owner's representative's information mentioned above, the Contractor shall confirm their agreement or indicate difficulties, if any, for the staying of the personnel. Thirty (30) days before the arrival of the Owner/Owner's representative's personnel in the training site, the Owner/Owner's representative shall inform the Contractor of the brief career profile of the personnel including names, date of birth, nationality, specialisation, experience, qualification, position and knowledge of foreign languages for their reference / information.

The Contractor shall not charge the Owner/Owner's representative the costs for the training activities in the respective training sites.

#### **19.0.0 PROGRESS REPORTS**

##### **19.1.0 Reports during design and procurement**


The Contractor will submit a progress report each month, within the first 7 days of each month, which indicates the following aspects as a minimum:

- Executive summary
- Work completed last month
- Status of design and its approval
- Status of procurement, manufacturing, works test, shippings
- Status of permission from authorities
- Time schedule, indicating progress achieved
- Preview, indicating major activities, design meetings.
- Areas of concern

##### **19.2.0 Report during Site Erection, Start-up, Testing**

The intervals for report submission shall be decided jointly between Owner/Owner's representative and Contractor in addition to the aspects mentioned above, the following information should be added:

- Site safety report
- Photos showing erection progress
- employed personnel / equipments / cranes

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- Preview on tests to be performed, start-up requirements.

**20.0.0 PLANT PERFORMANCE GUARANTEES**

**20.1.0 Reference Condition**

The plant performance guarantees to be provided during Performance Test shall be based on the following at .Site reference conndtions as per clause 9.6.3.2 above

- The “Gross power output” of the plant shall be the measured output at the outgoing terminals of the Generator and shall exclude excitation power.
- The heat rate shall be referred to the gross power output at site reference conditions.
- The plant shall be capable of operating at any ambient conditions prevailing at site as per specification without imposing any limitation on the specification requirements. However, the maximum power the plant can generate may be limited by the capacity to which the gas turbine is normally designed but shall at least be equal to its unrestricted capability at ISO conditions.

**20.2.0 Auxiliary Power Consumption of the plant**

The Contractor shall guarantee the power consumption of all continuously operating auxiliaries, which are required for the operation of the power plant at base load and transformer losses. The Bidder shall list the auxiliary power consumption separately for each equipment/system. Bidder shall provide correction procedure for variation in auxiliary power consumption for variation in ambient conditions and other reference conditions indicated above, as applicable.

**20.2.1 Equipment / system to be considered for guaranteed auxiliary power consumption**

**20.2.1.1 Definition of guaranteed auxiliary power consumption**

Guaranteed auxiliary power consumption shall mean the total electrical power consumed by the plant during normal operation, the plant generating guaranteed gross power output in combined cycle mode.


Equipment / systems need not be considered for guaranteed auxiliary power consumption

Lighting loads in areas other than specified below.

The performance test shall be conducted during daytime. However, all lighting in the following areas shall be switched “ON” while carrying out the Performance Guarantee Tests but not limited to :-

- GTG/STG Building
- Switchgear room
- Cable spreader room
- GTG/STG Control room
- GIS building
- GIS control room
- SWAS Room
- Air compressor/Workshop

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Following equipment / systems also to be considered for guaranteed auxiliary power consumption

- CCW pumps
- ACW pumps
- Side Stream Filter (SSF) pumps
- DM water transfer pump
- BFP pumps
- CEP pumps
- Lube oil Pumps & Jacking Oil pumps.
- Compressed air system (CAS)

**20.2.1.2 Measurement of auxiliary power consumption**

To arrive at the Gross Power output of the plant, the Gross Power output of each generator shall be measured. The power to be measured/recorded at following locations to arrive at the auxiliary power consumption of the power plant-

- a. 11 KV CCCPP auxiliary switchgear incomer,
- b. Outgoing auxiliary transformer feeders
- c. Outgoing motor feeders for the power Plant
- d. Outgoing feeders to the complex

**Auxiliary power consumption of CCCPP will be measured at individual 11 kV auxiliary feeders of 11 kV CCCPP auxiliary switchgear (11 kV CCCPP motor feeders and auxiliary transformer feeders). Individual auxiliary consumption of 11 kV auxiliary feeders shall be summated and to be displayed at 11 kV switchgear as well as at Sub-station Automation System (SAS).**

All equipment / systems including transformer losses, busduct losses, switchyard losses etc., in the power plant shall be considered for guaranteed auxiliary power consumption.

**20.3.0 Heat Balance Data**

The Bidder shall furnish the heat balance diagrams as specified in Vol-IV / Section 7 (Technical Data sheets and Schedules to be filled in by the Bidder).


**21.0.0 PENALTY FOR SHORTFALL IN PERFORMANCE**

The Contractor shall provide guaranteed performance for the complete works and the values guaranteed shall be binding on him. The Contractor shall conduct performance test as described in contract document and prove the guarantees.

The terms under Guarantee fall under two categories:

- A. Items for which penalty will be leviable for shortfall in Performance.
- B. Items for which shortfall in performance is not acceptable and which must be corrected at no extra cost to the Owner/Owner's representative.

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**21.1.0 Items for which penalty will be leviable for Shortfall In Performance**

**21.1.1 Simple Cycle Mode – Not applicable**

**Gross Power Output**

If the measured gross power output of the generator terminals falls short of the guaranteed gross power output under simple cycle mode, the penalty levied shall be as below:

Per kW shortfall : Rs. -

**Auxiliary Power Consumption**

If the measured auxiliary power consumption is in excess of the guaranteed auxiliary power consumption under simple cycle mode, the penalty levied shall be as below:

Per kW increase in Auxiliary power Consumption : Rs. -

**21.1.2 Combined Cycle Mode**

**Gross Power Output**

If the measured gross power output of the generator falls short of the guaranteed gross power output, the penalty levied shall be as below:

Per kW shortfall in Combined Cycle : Rs. **56192**

**21.1.3 Auxiliary Power Consumption**

If the measured auxiliary power consumption is an excess of the guaranteed auxiliary power consumption, the penalty levied shall be as below:

Per kW increase in Auxiliary power consumption in Combined Cycle : Rs. **67010**

Penalties for not meeting performance guarantees during the Performance guarantee tests shall be assessed and recovered by the Owner/Owner's representative from the Contractor as detailed above. Such penalties which are in addition to any other damages provided for in these General Conditions of Contract shall be assessed at the rates and subject to the other conditions set forth in the General / Technical Specifications.


**21.1.4 Gross Heat Rate**

If the gross heat exceeds the guaranteed heat release rate during performance & guarantee tests , the penalty levied will be as follows

For every excess in kcal/kwhr Rs. **20,00,000**

If the total penalty for shortfall and/or in excess of guaranteed performance figures is upto 5 % of contract price, the plant / system will be accepted after levying the penalty as specified. If the total penalty exceeds 5 % of the contract price, contractor shall carry out necessary modification to make the system comply with guaranteed requirement. However, if the contractor is not able to demonstrate the guaranteed values even after the modification within 90 days of notification by the Owner/Owner's representative, the Owner/Owner's representative

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may at his discretion reject the plant and recover the payment already made for the entire contract or accept the equipment after levying the penalty at actuals.

**21.2.0 Items with no permissible deviation on Guarantee**

For the items indicated below under guarantee shortfall in performance is not acceptable and shall be guaranteed by the Contractor as under compulsory correction. The performance shall be proved under worst grid conditions and/or at variation in fuel composition as specified.

1. Vibration limits for the gas turbine, steam turbine and auxiliaries
2. Noise levels for the gas turbine, steam turbine and auxiliaries
3. Emission level as specified.
4. HRSG steam purity.
5. Capacity of condenser air evacuation plant.
6. Oxygen Content at condenser and deaerator outlets at all specified loads of operation.

For the items indicated above the Contractor shall carry out modifications to obtain the guaranteed performance in case they exceed the permissible limit. As these are primary parameters, they must be corrected even before reliability run is started. And further, these parameters must remain stable throughout the period of reliability run. All works related to correction and subsequent reliability run to prove the stability/reliability shall be completed within the guarantee period with no extra cost to the Owner/Owner's representative.

If finally, in spite of all practicable effort on the part of the Contractor, the stipulated guarantees on these parameters are not established, the Owner/Owner's representative retains the option to reject the equipment. In case the option to reject is exercised by the Owner/Owner's representative which will be binding on the Contractor, the Contractor shall replace the rejected equipment within a reasonable period of time as will be indicated by the Owner/Owner's representative and achieve the performance as guaranteed in the contract.

**22.0.0 BID EVALUATION CRITERIA**

Refer relevant portion in Volume I – Commercial Specifications.

**23.0.0 INTERFACE / HOOK-UP POINTS**


**23.1.0 Mechanical:**

Refer Plot Plan Drg. no 00-5111168-G-001 Rev B , P & ID for HP/MP/LP Process Steam System Drg. No. 20-5111168-M-022 Rev B & Hook-up Details Dwg. No 20-5111168-M-023 Rev B, enclosed with the specification for location & other details.

**23.2.0 Electrical:**

1. Approximately 10 Nos. (minimum) plant feeders presently connected to existing 11kV switchgear located in the MRSS (Main receiving substation) shall be disconnected and shall be reconnected to new 11kV switchgear of CCCPP. Feeders to be shifted will be identified by the Owner/Owner's representative. Also additional 15 Nos. breaker panel feeders on each bus (Total 30 no. feeders) shall be provided in the new 11kV switchgear for future use.
2. All Power & control cabling shall be disconnected from existing switchgear and reconnected to new 11kV CCCPP switchgear. Cable joints to be considered for power cables and new control cables to be provided. Necessary cable trench, cable racks, cable trays & necessary supporting arrangements to be included in EPC contractor's scope.
3. Existing 66kV transmission line conductor (DOG) for two nos. incoming feeders from GETCO, Ichhapore substation is around 4 KM route length. These conductors shall be replaced with a

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**SECTION - 5.0**

**DETAILED TECHNICAL SPECIFICATION**


**CIVIL, STRUCTURAL AND ARCHITECTURAL WORKS**

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## SECTION - 5.0

### CIVIL, STRUCTURAL AND ARCHITECTURAL WORKS


#### 5.1.0 GENERAL

This specification covers the design, detailing, supply, construction / erection, testing and commissioning of all Civil, Structural and Architectural Works for the Power Plant.

If any provision of this specification departs from the Bidder's standard design and construction practice sufficiently to materially increase the cost of construction without in his opinion providing corresponding increase in quality/reliability or if he considers that his usual design and construction would provide better quality/reliability, he shall offer the particular work/system based on his standard design and construction method. The proposed deviations from this tender shall be specifically highlighted in a standard format for technical deviations & only agreed deviations will be a part of the contract. Deviations mentioned elsewhere in the offer will not be accepted. In case such offer with deviations is made, the Bidder shall state very clearly the merit of his offer and the demerits (in his opinion) the specified design has. However, the Contractor shall stick to the same design and construction philosophy that he has offered, if accepted by the Owner/Owner's representative and shall not make any changes during execution.

The design and construction specifications included in this section are intended to cover the general design and construction quality requirements. It is not intended to cover the minute details. The Standard Technical Specifications for Construction included under Clause 5.5.0, cover the quality and workmanship requirements for the various materials and types of work. The specific material and type of work to be adopted for this project are specified in Clause 5.4.0 hereunder. In case the same is not specified, the Contractor shall indicate in his offer, the material and specification he proposes to adopt for such works and get the same approved. In case construction requirements for any item specified in Design Specifications are not covered in the Construction Specifications, the manufacturer's specification / recommendations, other International Standards or good Owner/Owner's representative's practice (but not contradictory or inferior to Indian Standards), as approved by Owner/Owner's representative, shall be followed. In case of any contradiction between the provisions of Clause 5.5.0 and Clause 5.4.0, the more stringent of the two shall govern. In all cases, the decision of the Owner/Owner's representative shall be final & binding.

Any reference to unit rates, Schedule of Item, Bill of Quantities, etc. if found, in the Standard Technical Specification under Clause 5.5.0 shall be considered as not applicable, as this is an EPC tender on lump sum basis. Units of linear dimensions, sizes etc. referred in this specification shall be in millimeters (mm) unless otherwise specified.

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## 5.2.0 SCOPE OF WORK

### 5.2.1 General

This section sets out the scope of necessary surveys and investigations, design, supply, construction, installation, testing and commissioning of Civil, Structural and Architectural works, without excluding necessary components and services not mentioned.

The scope shall include the demolition and removal of existing underground structures or any obstructions which are necessary for the execution of work.


The scope shall include other related works although they may not be specifically mentioned in the subsequent clauses and all such incidental items not mentioned, but are necessary for completion of the work as a whole. The Contractor shall supply all materials including cement, reinforcement steel and Structural steel. Each consignment of materials shall be tested at Government approved laboratory. All costs, royalties, taxes & duties, octroi, transportation etc. towards building materials shall be paid by the Contractor. Since this is an EPC contract, no work or supply shall be done by other agencies including the Owner/Owner's representative.

The scope also includes supply of all labour, technical personnel, materials and equipment for execution of work and getting all materials tested at site laboratory or approved laboratory outside, submitting test reports, arranging supervision of manufacturer for specialized items. After award of work the Contractor shall submit for Owner/Owner's representative's approval a detailed quality assurance programme for all the materials and types of works.

The intending Bidders are advised to visit the site to have a firsthand information about the site conditions such as access to site, access for construction and erection, clearance available, availability of material (e.g. aggregate, sand, bricks etc.) and all other relevant details before submission of tender. Non familiarity with the site conditions will not be considered a reason either for extra claims or for not carrying out work in strict conformity with time schedule, drawing and specifications.

### 5.2.2 Buildings, Structures and Facilities covered in the scope

- Chain link fencing around transformer yards including Gate
- Earthwork and filling in proposed power plant area as per grading drawing.
- Micro Site Grading and levelling
- BM main approach road from the existing road to the proposed plant area.
- Plant Internal BM roads and paved areas
- RCC Storm Water Drainage System on both sides of road along with pre- cast RCC covers and interconnection of drains to existing system wherever applicable.
- Gas Turbine and Generator / STG Building shed
- Gas Turbine Foundations
- Gas Turbine Area Equipment Foundations
- HRSG Foundations
- Steel Chimney and foundation.
- Steam Turbine Foundations
- Switchgear and Control Buildings
- Transformer Foundations
- Gas Insulated Switchyard Structure and Foundations, cable trenches, roads, gravel filling etc
- Fuel Gas Conditioning Station
- Blackstart cum Emergency DG Set Building
- CW Pump Shed and forebay

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- Mechanical Induced draft Cooling Towers
- Civil works related to Water Pipeline and Effluent disposal line
- Compressor house
- Service Water and Potable Water overhead tank
- Neutralization pit
- Chemical Laboratory
- Chemical House.
- HRSG Blowdown sump
- Pipe and Cable Racks
- Pipe and Cable Trenches
- Air washer room
- Sewage Disposal System
- Guard pond and with associated pumps and piping structures up to existing pit
- Lighting towers minimum 4 nos. of suitable height.
- Green belt area as per Statutory norms
- Any other buildings / structures required from system considerations.
- Watch towers with security lights
- Floor drains and sump with associated pumps.
- Temporary barricades/structures to protect the existing plant

Scope of work shall cover, but not limited to the following major items.

### 5.2.3 Survey and Investigation

Topographical survey & Geo-technical Report on the investigations carried out by Owner/Owner's representative shall be made available to intending Bidders for information with no liability on the accuracy of the information furnished in the reports. Additional investigation shall be carried out to substantiate the results of the investigation already carried out or to obtain specific soil properties not covered in the specification or soil report shall be carried out by Contractor during detailed engineering stage at no extra cost to Owner/Owner's representative. Contractor will be required to carry out investigation as per the decision of the Owner/Owner's representative, without any price implication. Such report/Investigation carried out by the Contractor shall be submitted to the Owner/Owner's representative for approval before proceeding with further engineering.

Plant grading, levelling, tree cutting, thorny jungle clearance as required. The grade level shall be maintained considering the elevation of the existing Plant level.


The surplus earth material after excavation shall be disposed in a lead of 5.00 KM radius without any extra cost.

- Fencing shall be provided to all areas where there is risk to human life or entry restriction is essential for safety purpose.

Chain link fencing at critical area as identified in the plot plan and as specified in specification.

### 5.2.4 Design and Engineering

- Preparation and submission of design calculations and construction drawings and getting the same approved by the Owner/Owner's representative.
  - a) Design criteria for Civil, Structural and Architectural works.
  - b) Design Calculations for road and drains

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- c) Structural calculations including analysis for structures and foundations.
- d) Hydraulic calculations for drains.
- e) Static and Dynamic analysis for machine foundations
- f) Calculations for piles
- g) General Arrangement and Reinforcement drawings for concrete works
- h) Architectural and joinery details for buildings
- i) Layout and details for outdoor facilities - Roads, Paving, drainage, sewerage, cable / pipe trenches, duct banks etc.
- j) General Arrangement and fabrication drawings for steel structures
- k) Architectural floor plans including conceptual interior/ equipment and furniture arrangement, elevations, cross sections and perspective view in colour of all buildings (i.e.) for GT/ST common control room etc., including provision of natural light for GT / ST buildings. Bidder shall submit two different schemes along with a report elaborating the underlying philosophy of the proposed architectural concepts.

- Preparation and submission of design and drawings for statutory approvals from local Municipal / Panchayat authorities, Factory Inspector, Civil Aviation Authorities and other authorities, as applicable.


Obtaining necessary details, permission and approvals from statutory authorities for carrying out the work. Owner/Owner's representative will issue necessary authorization letter and extend necessary help for the above to the extent possible.

### 5.2.5 Construction

- Construction of, Fences and Gates


The demolition and removal of existing (above ground / underground) structures or any obstructions which are necessary for the construction/execution of work.

- Tree cutting, thorny jungle clearance as required to the site, Earthwork in filling and site grading of the Power plant area to the finished ground level shall be as per drg no **10-5111168-C-002 (Rev B) – Site grading plan (Ref Volume IV & Section No. 06 of Technical specification).**
- Construction of temporary buildings and structures for Contractor's use, such as Site Office, Cement Godowns, and Storage yards, Canteen, Construction Material Testing Laboratory and other facilities as required.
- Construction of roads, peripheral walkways, drainage, sewerage, culverts, duct banks etc. within the Power Plant. Interconnection of above systems to existing systems wherever applicable.
- Earthwork in excavation including rock quarrying/blasting if required, identifying borrow pits, transportation of soil from borrow pits, backfilling, disposal of excavated soil to designated areas within and outside the plant boundary etc. Archeological findings, if any, shall be reported to the Owner/Owner's representative.

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	<ul style="list-style-type: none"> <li>- Installation of trial piles, test piles and permanent working piles if required as per Geo-technical Report and its recommendations / interpretations.</li> <li>- Pre-constructional Anti-termite treatment as specified.</li> <li>- Civil, Structural and Architectural and finishing works for all buildings and structures.</li> <li>- Sanitary and plumbing works for all buildings.</li> <li>- Construction of all foundations and structures in RCC and steel work for all the buildings and facilities of the Power Plant.</li> <li>- Construction of all equipment and machine foundations</li> <li>- Construction of Steel chimney</li> <li>- All other works required for completion of the project in all respects.</li> </ul>
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### 5.3.0 Design Criteria for Civil, Structural and Architectural Works

This subsection covers the general design requirements related to Civil, Structural and Architectural works

#### 5.3.1 Design Criteria - Codes and Standards

The following Indian Codes and Standards shall be generally used for design of civil and structural works. In all cases, the latest revisions with amendments, if any, shall be followed. For work not covered by Indian Standards, other International Standards, as applicable shall be followed. In case where either Indian or International standards, are not available, good engineering practice, as approved by the Owner/Owner's representative shall be followed.

Reference of only some of the codes in this document and various clauses of design criteria shall not limit or restrict the scope or applicability of other relevant codes. It shall be ensured that all other codes relevant to a specific job, in addition to those already mentioned, are followed wherever applicable.

In case of any deviation / conflict between provisions of IS codes and the design criteria, the provisions that are more stringent shall be followed unless specifically directed otherwise.

The Codes and Standards listed below are applicable for the design of structures and buildings in general. Codes and Standards applicable for specific design and construction are listed elsewhere in respective sections.

#### General


- IS: 875 Code of practice for design loads (other than earthquake) for buildings and structures.
- IS: 1893 Criteria for earthquake resistant design of structures.
- IS: 4326 Earthquake design and construction of buildings - Code of Practice.

#### Foundations

- IS: 1080 Code of practice for design and construction of shallow foundations in soils (other than raft, ring and shell).
- IS: 1904 Code of practice for structural safety of building foundations.
- IS: 2950 Code of practice for design and construction of raft foundations.
- IS: 2974 Code of practice for design and construction of machine foundations.
- IS: 6403 Code of Practice for determination of bearing capacity of shallow foundations.
- IS: 8009 Code of Practice for foundation settlement calculations.
- IS: 13301 Guidelines for vibration isolation for machine foundations

#### Concrete Structures

- IS: 456 Code of practice for plain and Reinforced concrete.
- IS: 3370 Code of practice for concrete structures for the storage of liquids.

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- IS: 3414 Code of Practice for design and installation of joints in buildings
- IS: 4326 Code of Practice for earthquake resistant design and construction of buildings
- IS: 5525 Recommendation for detailing of reinforced concrete works
- IS: 6313 Code of practice for anti-termite measures in buildings
- IS: 13920 Ductile detailing of Reinforced Concrete Structures subjected to Seismic forces.

**Steel Structures**

- IS: 800 Code of practice for use of structural steel in general building construction.
- IS: 802 Code of Practice for use of Structural Steel in over Head Transmission Line Towers.
- IS: 806 Code of practice for use of steel tubes in general building construction.
- IS:808 Dimensions for hot rolled steel beam, column channel and angle section
- IS:813 Scheme of symbols for welding
- IS:816 Code of Practice for use of metal arc welding for general construction in mild steel

**Miscellaneous**

- IS:1172 Code of basic requirements for water supply, drainage and sanitation
- IS:1742 Code of Practice for building drainage
- IS:1905 Code of Practice for structural use of un-reinforced masonry
- IS:2470 Code of Practice for installation of septic tanks
- IS:3067 Code of Practice for general design details and preparatory works for damp proofing and water proofing of buildings
- SP:6 Handbook for structural engineers (all parts)
- SP:7 National Building Code of India
- SP:16 Design Aids for reinforced concrete to IS:456
- SP:20 Handbook on masonry design and construction
- SP:22 Explanatory handbook on codes for earthquake engineering
- SP:24 Explanatory handbook on Indian Standard Code of Practice for plain and reinforced concrete
- SP:25 Handbook on causes and prevention of cracks in buildings
- SP:32 Handbook on functional requirements of industrial buildings

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- SP:34 Handbook of concrete reinforcement & detailing (SCIP)
- IRC:37 Guidelines for design of flexible pavements
- IRC:58 Guidelines for the design of rigid pavements for highways
- IRC:73 Geometric design of roads

### 5.3.2 Design Criteria – Architectural and Finishing Works

#### Architectural Design

Architectural design of the buildings shall be in conformity with the following:

- Architectural design basis.
- National Building Code of India
- Local Municipal or other authority by-laws.
- Relevant state Government Factory Acts.
- Tariff Advisory Committee (TAC) recommendations
- Any other relevant information included elsewhere in this tender.

#### Space Requirement

Space requirement shall be based on one or combination of the following depending upon the specific situation.

- a. Occupancy
- b. Equipment layout
- c. Storage / operational requirement

#### Layout

Layout and detailing shall be developed in compliance with the relevant statutory regulations and good industry practices.


#### Design Consideration

Architectural design shall be developed within the frame work of space availability and layout taking into account of load conditions as well as local Architectural practices.

Architectural design of all buildings shall fully meet the functional requirement. Buildings shall be adequately sized and provided with sufficient passageways and access, ventilation and natural lighting for carrying out the desired activity and operations smoothly. An overall architectural control and harmony shall be maintained among all the buildings of the project. All plant and non-plant buildings shall have minimum two accesses.

#### Circulation

All buildings and open plant areas must be approachable by roads / paved pathways of required widths to suit the openings / approach to the buildings and shall lead up to entry points. Necessary car parking space shall be provided near the buildings. All internal corridors / passage inside the building shall have a clear width of minimum 1800 mm unless otherwise specified. All firefighting equipment etc. shall be provided in suitable niche as per requirements.

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**Ventilation**

Provision for natural ventilation and lighting as also for mechanical ventilation, pressurization, air conditioning shall be provided taking into consideration the local conditions, the activity and equipment in the building, statutory requirements and specific requirement, if any. Generally openable windows of area not less than 20% of the floor area shall be provided for natural ventilation. All outside doors, windows shall be adequately protected by sunshade (min.750 mm projection sunshades shall be provided with drip mould). The area of ventilation shall not be less than as specified / statutory requirement. Exhaust fan shall be provided in Toilet & battery room areas. 50 mm thick R.C.C. jali / ventilators / louvers shall be provided in cellar areas for ventilation.

**Acoustic Treatment**

Suitable acoustic treatment shall be incorporated in the architectural design to ensure that the noise generated shall satisfy the ambient noise level standard prescribed by the Pollution Control Board.

**Architectural Requirements**

**Toilets**

Toilets shall be provided near work areas, but isolated from main areas. Unless otherwise shown in drawings or specified, the dimension of the toilet blocks shall be decided by the number of sanitary fixtures, which shall be based on number of users in accordance with IS: 1172. Provisions of Factories Act / Local regulations with respect number of toilets and separate toilets for Ladies shall be complied with.

Toilets shall be provided with all necessary approved Indian Standard fittings. The floor of toilet shall have a drop of 15 mm from general floor level and shall have sufficient slope towards drain trap. Sufficient natural light and ventilation shall be provided as per requirement. Unless specified each toilet shall be provided with minimum one W.C. (water closet), one urinal, one washbasin, towel rail, mirror and liquid soap container, glass shelves etc. Western/Indian style water closets shall be provided as specified / directed by the Owner/Owner's representative. Urinals shall be without photovoltaic control flushing system.


**Ramps**

Ramps shall be provided for equipment entry. Slope shall not be steeper than 1:7, unless otherwise specified.

**Stairways**

All buildings must have access to roof by means of stairs / cage ladder. Access to roof shall be through stairways for multistoreyed buildings and for single storeyed buildings which require frequent access. All R.C.C. staircases shall have a minimum stair width of 1200 mm with hand railing on one or both sides as per requirements. Tread and riser shall be properly maintained to ensure comfortable climb. The nos. of stairs to be provided shall be as per statutory requirement / TAC recommendations. All approachable terraces shall be provided with 1000 high parapet wall. Non-approachable terraces or terraces where access is provided by ladders only, shall have min. 115 thick, 350 high parapet wall.

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### Layouts of plant buildings

The layout of the buildings shall be developed considering the equipment layout, such as electrical panels, mechanical equipment etc. with due consideration for working space, maintenance space requirement, statutory clearances, etc. All buildings shall be protected with 1000 wide plinth protection all around the building.

The height of the buildings shall be provided as per the statutory requirements and equipment / crane / mono-rail requirement.

The location, numbers, dimensions and types of access doors, windows / rolling shutters shall be decided based on equipment layout, ventilation, operational and maintenance requirements. Fireproof doors shall be provided at fire exits with fire rating of 2 hours. Cable galleries shall be provided with fireproof wall rated for 2 hours.

Generally the building floors shall be 500 mm above the finished ground level of the respective areas.

### Masonry walls

The external brick wall for the buildings shall be 230 mm thick and internal walls 230/115 mm thick as per requirement. The requirement of fire barrier wall between transformers shall be as per Electricity Rules and TAC recommendations but shall not be less than 350 mm thick. In case wall heights are more than 5 metres, RCC walls shall be provided and minimum thickness of the same shall be 230 mm. Internal plastering shall be 12 mm thick in mortar 1:3 and external plastering shall be 20 mm (in two layers) in cement mortar 1:3 for 230mm thick brick wall. 115mm thick brick wall will be plastered with 12mm thick cement mortar 1:3. Half brick internal walls shall be provided with 2 nos. of 6 mm dia steel bars reinforcement at every fourth layers. Damp proof coarse 40 mm thick in PCC 1:2:4 using 6 mm down stone shall be provided in the external brick walls at grade level. Ceiling plastering shall be 6mm thick with cement mortar 1:3.

### Architectural and Finish Specification

The specification furnished below shall be applicable for architectural works as well as for finishes to concrete surfaces wherever specified.

Minimum size of single shutter door shall be 1200 mm x 2100 mm. For higher widths double shutters shall be provided. Maximum size of double shutter doors shall be restricted to 2000 mm x 2500 mm beyond which Rolling shutters shall be used.


#### a. Doors, Windows, Ventilators, Louvers and Rolling Shutters

##### Steel Door

- Double plated flush doors 45 mm thick with 18 gauge pressed steel frames conforming to IS: 4351 and 18 gauge plain steel sheets on both faces.
- Fixtures and other details as per specifications.

##### Timber Door

- Teakwood frames.
- 38 mm thick solid core teakwood flush shutters conforming to IS: 2191 with commercial quality teak ply and vision panel for flush doors.

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- 38 mm thick paneled shutters with 15 mm marine board panels (and plastic sheet on inside face for paneled doors for toilets. Minimum width of toilet doors can be 800 mm.
- Fixtures and other details as per specifications.

**Aluminum doors, partitions & windows**

- Extruded aluminum box section for frame and shutter with minimum thickness of 2.5 mm
- 4 mm thick plain glass for openable shutters
- 6 mm thick plain glass for fixed shutters.
- 6.3 mm thick laminated safety glass for fixed glazed partitions.
- Fixtures and other details as per specifications.

**Steel Windows / Ventilators**

- Steel windows of standard dimensions conforming to IS: 1361.
- 4 mm thick plain glass for openable shutters
- 6 mm thick wired glass for fixed shutters.
- 12 mm sq. MS safety bars @ 100 mm c/c.
- Fixtures and other details as per specifications.

**Steel Louvers**

- Pressed steel louvers from 18 gauge steel sheets and MS rolled channel frame.
- Fixtures and other details as per specifications.

**Rolling shutter**

- PVC Coated shutter made from 18 gauge steel sheets, suitable for saline weather conditions. Guides 75 mm x 25 mm steel channel.
- Details as per IS:6248,


**b. Floor finishes**

**Indian Patent Stone (IPS) flooring**

- 28 mm thick under bed in PCC 1:2:4 with 10 mm downgraded granite stone chips
- 12 mm thick topping. One (1) part of metallic hardener shall be mixed dry with 4 parts of cement by volume. To this mixture, 6 mm nominal size stone chips shall be added in portion of 1:3 (mixture of hardener & cement : stone chips) by volume.

**Cast-in-situ terrazzo flooring**

- 25 mm thick under bed in PCC 1:1.5:3 with 10 mm downgraded granite stone chips.

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- 15 mm thick terrazzo topping with 6 mm down marble chips of approved color.
- Panel size 1000 mm x 1000 mm with 40 mm x 3 mm thick glass dividing strip.

**Precast Terrazzo tiles**

- 20 mm thick underbed in PCC 1:1.5:3 with 10 mm down granite stone chips.
- 250 mm x 250 mm x 20 mm tiles.

**Carborundum tiles**

- 20 mm thick underbed in PCC 1:1.5:3 with 10 mm down granite stone chips.
- 250 mm x 250 mm x 20 mm tiles.

**Acid Resistant Tiles**

- 15 mm thick underbed in cement mortar 1:3.
- Intermediate layers of 3 mm thick bitumen and 6 mm thick acid proof mortar.
- 25 mm thick acid resistant tiles conforming to IS:4457.

**Glazed Tiles**

- 15 mm thick underbed in cement mortar 1:3
- Earthenware glazed tiles conforming to IS:777.

**Heavy duty Ceramic Floor Tiles**

- 15 mm underbed in cement mortar 1:3
- Ceramic floor tiles 600x600x10.

**PVC Tiles**


- 37 mm thick underbed in PCC 1:2:4 in areas without false flooring.
- To be directly installed over particle board tiles in false floor areas.
- 2 mm thick PVC tiles over false flooring and 3.02mm in other areas conforming to IS:3461/IS:3462.

**Granite tiles**

- 15 mm underbed in cement mortar 1:3
- 20 mm thick black color premium quality hard polished granite.

**Vitrified Floor Tiles**

- 12 mm underbed in cement mortar 1:3
- 300 mm x 300 mm x 6 mm or 300 mm x 200 mm x 6 mm Vitrified floor tiles (MARBONITE or approved equivalent).

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**Epoxy coating**

- Details as per detailed specification covered in Clause 5.5.0.

**c. Roof finishes**

**Roof waterproofing with pressed flat tiles**

- 80 mm (min) thick layer of brick jelly lime concrete 1:2:4 using 20 mm downgraded brick bats.
- 20 mm thick underbed for tiles in cement mortar 1:3 with waterproofing admixture.
- 20 mm thick pressed flat tiles

**Roof waterproofing with polymeric membrane**

- 40 mm (min) thick screed layer in PCC 1:2:4 using 20 mm downgraded brick bats.
- Bituminous polymeric membrane as per specification or approved equivalent.
- 20 mm thick cement mortar 1:3 with chicken mesh over membrane.

**Basement damp proofing with polymeric membrane**

- Bituminous Polymeric membrane or approved equivalent as per specification.
- Vertical faces protected with 115 mm thick brick wall.

**d. Painting**

**Oil bound distemper**


- One priming coat of cement primer or any other suitable primer as per manufacturer's recommendation.
- Two final coats of paint conforming to IS:428 to obtain even finish and uniform color.

**Synthetic enamel**

- One coat of Red oxide zinc chromate primer 25 microns thick.
- Two final coats of paint conforming IS:2932 each 25 microns thick.

**Acrylic Plastic Emulsion**

- One filler coat with **plaster of Paris 3 mm thick.**
- Two coats of suitable primer as per manufacturer's recommendation.
- Two final coats of paint to obtain even finish and uniform color.

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**Waterproof Cement Paint**

- One coat of paint as primer
- Two finish coats of paint to obtain even finish and uniform color.

**Apex Ultima/Exterior weather shield**

- One coat of paint as primer
- Two finish coats of paint to obtain even finish and uniform color.

**White washing / color washing**

- Three coats of white washing or color washing to obtain a uniform finish or shade.

**Chlorinated Rubber Paint**

- Two coats of high build chlorinated rubber zinc phosphate primer each 30 microns thick (for steel surface). One coat of chlorinated rubber paint (for concrete/masonry surfaces).
- Two final coats of chlorinated rubber paint each 40 microns thick.

**High build Epoxy paint**

- One coat of epoxy zinc phosphate primer 35 microns (for steel structure). Thin coat of epoxy high build paint (for concrete structure).
- Two finish coats of epoxy high build paint.

**High build Coal Tar Epoxy Paint**


- Two coats of epoxy red oxide zinc phosphate primer each 30 microns thick for (steel surface). One coat of epoxy sealer (for concrete surface).
- Two finish coats of high build coal tar epoxy paint.

**Chemical Resistant Phenolic based enamel**

- One coat of red oxide zinc chromate primer 25 microns (for steel surfaces).
- One thin coat of chemical resistant phenolic based enamel (for concrete surfaces).
- Two finish final coats of chemical resistant enamel each 25 microns.

**Acrylic Polyurethane Paint**

- Two coats of epoxy, zinc chromate primer each 35 microns thick (for steel surfaces)
- One coat of epoxy sealer (for concrete surfaces)
- Two finish coats of Acrylic Polyurethane paint each 30 microns thick.

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**e. Underdeck Insulation**

- 40 mm thick bonded mineral wool conforming to Group I of IS: 8183 with aluminium foil facing.

**f. False Ceiling**

LUXALON suspended by galvanised stud wire hangers.

**g. False Flooring**

600x600x32 mm cement fill metallic false flooring panel with 1.2 mm antistatic high pressure laminate tile on top.

- Base Plate size - 100x100x10 mm
- Seamless pipe - 25 mm OD
- Support Stud size - M18x 100 mm

**h. Sheeting**

**Permanent colour coated sandwiched insulated metal cladding and roofing system**

Troughed zinc - aluminum alloy coated (both sides) MS sheet having 0.8 mm minimum thickness (or high tensile steel sheet of 0.5 mm minimum thickness) shall be used on external face (outer face) of cladding system. Weight of coating shall not be less than 150 gm /sq.m. The outer side (exposed face) shall be permanently colour coated with Polyfluro Vinyl Coating (PVF2) of Dry Film Thickness (DFT) 40 microns (min) over primer. Inner side of external sheet shall be provided with suitable pre-coating of minimum 7 microns.

Double dip Galvanized (475 gsm) MS sheets of minimum 0.8 mm thickness shall be used as inner liner (internal face) of cladding system. The exposed face shall be permanently colour coated with silicon modified polyester paint of DFT 40 microns (min) over primer. Inner face of external sheet shall be provided with suitable pre-coating of minimum 7 microns. The rate of galvanization shall not be less than 150 gm /sq .m.


The permanent colour coated sheet shall meet the general requirements of IS: 14246 and shall conform to class 3 for the durability.

Inner sheet shall fixed directly to side runners and Z spacers made of at least 2 mm thick galvanized steel sheet of grade 375 as per IS : 277. Inner sheet shall be fixed at the rate not more than 1.50 m center to center to hold the insulation and external sheeting.

The insulation shall be of bonded mineral wool of minimum thickness 50 mm conforming to IS : 8183, having a density of 32 kg / cu.m for glass wool & 48 kg /cu.m for rock wool.

For roof sheeting the specification remains the same as that of side cladding except the thickness and galvanization. The minimum thickness of roof sheeting shall be 0.8mm with galvanized rate of 275 gm/sqm.

Prefabricated sandwiched polyurethane PUF panel system may also be used for side cladding and roof sheeting.

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**Permanent colour coated (non-insulated) metal cladding system**

Troughed zinc aluminum alloy coated not less than 150 gm/sq.m M.S sheets having 0.6 mm minimum thickness (or High tensile steel sheet of 0.5 mm minimum thickness) shall be used for the cladding system. The outer side (exposed face) shall be permanently colour coated with PVF2 paint of minimum DFT 20 microns over primer and the inner side (internal face) shall be coated with same paint of minimum DFT 12 microns over primer. These shall be fixed directly to runners. The sheets shall meet the general requirement of IS: 14246 and shall conform to class 3 for the durability. For roof sheeting the specification remains the same as that of side cladding except the thickness and galvanization. The minimum thickness of roof sheeting shall be 0.8mm with galvanized rate of 275 gm/sq.m.

**Flashings, caps, trim closures etc.**

All flashings, trim closures, caps etc. required for the metal cladding system shall be made out of plain sheets having same material and coating specification as mentioned above for the outer face of the sandwiched metal cladding.

**5.3.3 Design Criteria - Plumbing and Sanitary Works**

**a. Water Supply**

**Materials**

- Water supply pipes shall be composite pipes of food grade quality
- Isolation valve (up to 50 mm) shall be of gun metal conforming to IS: 778 (Class II).

Valve pits for gunmetal valve shall be in brick construction.

**System**

- A water supply connection shall be made from nearby potable water main and the size of the same shall be decided based on fixture units.

**Fixture unit value for peak discharge**


Type of Fixture	Fixture Unit Value
1 Water closet	1
1 Bath	1/2
1 Wash Basin	1/2
1 Kitchen sink	1/2
1 Urinal	1/2

Fixture unit value = 9 liters/min.

Before entering the building, an isolation valve shall be provided on water supply line.

**Flushing Tanks**

- Provision of flushing tanks for each toilet shall be made having following storage capacities.

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<b>Fixture</b>	<b>Storage Capacity (Litres)</b>
----------------	----------------------------------

Per WC	15
Per Urinal	5

**b. Sanitary Fixtures**

Each toilet block shall have the following minimum sanitary fittings/facilities shall be of approved brand of the following sizes and specification. All fittings shall be of chromium plated brass (fancy type) unless specified.

- Indian Water Closet (IWC) - Orissa pan of size 580 mm conforming to IS: 2556.
- European Water Closet (EWC) - Conforming to IS: 2556 with plastic seats and low level PVC Cistern of 15 litres capacity.
- Urinals - Flat back half shell of size 610 mm x 410 mm x 380 mm including a pair of 250 mm x 125 mm white ceramic foot rest and shall be without photovoltaic control flushing system
- Wash basin - 550 mm x 400 mm conforming to IS: 2556 with chromium plated bottle trap.
- Mirror - 600 mm x 450 mm x 6 mm beveled edge mirror
- Glass shelve - 600 mm x 127 mm x 4 mm with chromium plated brackets.
- Towel Rail - Stainless steel 600x20 mm.
- Toilet paper holder shall be provided for each European closet
- Soap Holder - Stainless steel liquid soap holder cum dispenser

Janitor room


Provision of installation of water cooler outside the toilet

Provision of ventilation shaft.

**c. Sewerage**

**Materials**

- All horizontal buried soil and waste pipes shall be of stoneware or PVC, socket and spigot and shall conform to relevant IS.
- All vertical soil, waste and vent pipes shall be of PVC conforming to relevant IS.
- Manholes and gully trap chambers shall be in brick construction.

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**System**


- The system shall be designed on the principle of "TWO PIPE SYSTEM" having two separate vertical pipes namely Main Soil Pipe (MSP) and Main waste Pipe (MWP) receiving waste from number of Branch Soil Pipes (BSP) and Branch Waste Pipes (BWP)
- A BSP either shall have only one WC. to be connected to MSP or it shall receive discharge from number of urinals to be connected to MSP.
- A BWP shall receive waste from wash basins, baths, sinks, cooler areas, etc.
- Floor traps shall be provided to receive waste from waste pipes of various fixtures (except from WC. which shall be directly connected to MSP) and at locations where waste water is to be drained out.
- A MSP shall be directly connected to first manhole of an outside sewer.
- A MWP shall be discharged into first manhole through a gully trap.
- All vertical stacks and ventilating pipes shall be carried to a height of at least 1.5 meters above parapet and shall be provided with cowl on top.
- Gradient of the sewage piping shall be at least 1:200.

**Sizing**

The soil and waste pipe diameters shall be based on fixture units as given below:

**Fixture Units for Different Sanitary Appliances**

Type of Fixture	Fixture Unit Value as Load Factor
Water closet, tank-operated	4
Water closet, valve-operated	8
Urinal	4
Showers (group) per head	3
Wash basin ordinary	1
Kitchen sink, domestic	2
Floor trap	1
Drinking fountain	1/2

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**Recommended Pipe Sizes for Branches and Main Vertical Pipes (STACKS)**

Diameter of pipe (mm)	Max. Number of Fixture Units that may be connected to	
	Any Horizontal fixture branch	One stack of 3 stories in Height or 3 intervals
1	2	3
30	1	2
40	3	4
50	6	10
65	12	20
80	20	30
100	160	240
150	620	960

- Minimum size of BSP receiving discharge from WC. shall be 100 mm up to MSP/first manhole.
- Minimum size of BWP shall be 80 mm.
- Minimum size after gully trap up to first manhole shall be 100 mm.

**Gradients**

- The gradient of a horizontal branch shall be such that non-silting & non-scouring velocity is maintained.

**Disposal**

- Treated sewage can be used for horticulture. Treated solid wastes can be used as manure.

**5.3.4 Design Criteria – Loads & Load Combinations**

All structures shall be designed for the most critical combinations of dead loads, imposed loads, equipment loads, crane loads, steam piping (static & dynamic) and other piping loads, wind loads, seismic loads as per IS 1893 (**all parts**) and any other loading conditions which can occur during the design life of the facility.


Design loads shall comply with the requirements of IS: 875 & IS: 1893 as a minimum, unless more stringent requirements are specified herein. The following types of loads shall be considered in general for the analysis and design of structures and foundations.

**Dead Loads (DL)**

Dead loads consist of the weights of the structure complete with finishes, fixtures, partitions, wall panels and all equipment of semi-permanent nature including tanks, partitions, roofing, piping, cable trays, bus ducts etc.

Self-weight of materials may be calculated on the basis of unit weights given in IS: 875 (Part 1). The following unit weight of material shall be considered for computation of loads:

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<u>Materials</u>	<u>Unit Weight</u>
Plain Cement Concrete	24 kN/m <sup>3</sup>
Reinforced Cement Concrete	25 kN/m <sup>3</sup>
Structural Steel	78.5 kN/m <sup>3</sup>
Brick work	20 kN/m <sup>3</sup>
Cement Plaster	21 kN/m <sup>3</sup>
Floor finish	24 kN/m <sup>3</sup>

**Equipment loads (EQL)**

Equipment causing heavy concentrated loads shall be considered separately. Loading data shall be initially estimated from suppliers' catalogues or from similar equipment supplied for other projects and the same shall be later verified based on certified manufacturer's drawing. Where both concentrated and uniform loads cannot act simultaneously, the structure shall be checked for each condition of loading separately and shall be designed for the more critical condition. The loading considered for tanks and piping shall include hydraulic test load. Crane girders and supporting columns shall be designed for vertical and lateral loads as furnished by the manufacturer. In the absence of data from manufacturer, wheel loads are estimated from crane weights and capacity of the crane and lateral loads and impact factors are arrived at based on the recommendations furnished in IS:875. Laydown areas in the turbine and generator halls shall be designed for concentrated loads resulting from storage of equipment components during erection and maintenance, and such areas shall be identified by permanent marking.

Static and dynamic loads of major equipments shall be based on the manufacturer's data of the specified equipments. However, where the uniform floor live load adequately accounts for the equipment moving weight, the weight of such equipment as a dead load shall not be considered e.g. switchgear and control room floors are usually designed for a live load that includes the equipment weight.

While arriving at seismic forces, the equipment loads should be accounted as dead loads.

All equipments, tank and piping design loading shall include hydraulic testing loads. Weight of equipments, ducts, tanks, pipes, conduits etc. supported by structure shall include maximum possible loading conditions i.e. flooded material contents and associated impacts, test loading, anchorage and constraint effects.

Air duct loads shall include weight of insulation, duct attachments, dust accumulation loads, seismic or wind whichever is applicable and other loads as applicable.


**Imposed Loads (IL)**

**General**

Imposed loads noted below are the general equivalent uniformly distributed loads to account for equipment/piping/cable tray/erection loads etc. and personnel movement. Where the actual loads of the equipment exceeds in specific areas due to concentration of facilities, the same shall be substituted in lieu of the above loads, in which case a nominal live load of 5 kN/m<sup>2</sup> shall be considered in the adjacent areas not covered by the equipment.

Imposed loads in different areas shall include live loads, minor equipment loads, cable trays, small pipe racks/ hangers, erection loads, operation / maintenance loads etc. The loads considered shall not be less than that specified in IS: 875 (Part II).

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The loads listed hereunder are minimum live loads for the areas involved. Special use areas shall be investigated and loads revised upward as necessary. Floors and supporting members which may be subjected to heavy equipment live loads shall be designed on the basis of the weight of equipment or specifically defined live loads, whichever is greater.


**Roofs**

- |    |             |   |   |
|----|-------------|---|---|
| a. | Flat Roof   | : | 1.5 kN/m <sup>2</sup> for accessible roofs<br>0.75 kN/m <sup>2</sup> for non-accessible roofs |
|    |             | : | 5.0 kN/m <sup>2</sup> for accessible roofs with HVAC equipment                                |
| b. | Sloped Roof | : | As per IS : 875   |

**STG, GTG, Switchgear and Control Buildings**

- |                 |  |   |                      |
|-----------------|--|---|----------------------|
| Ground floor    |  |   |                      |
| -               | General  | : | 15 kN/m <sup>2</sup> |
| -               | Unloading bay  | : | Actual               |
| -               | Heavy equipment storage area                                   | : | 50 kN/m <sup>2</sup> |
|                 | Cable spreader rooms   | : | 5 kN/m <sup>2</sup>  |
| Operating floor |  |   |                      |
| -               | General  | : | 15 kN/m <sup>2</sup> |
| -               | Laydown area   | : | 30 kN/m <sup>2</sup> |
| -               | Rotor removal area   | : | 30 kN/m <sup>2</sup> |
|                 | Switchgear floor   | : | 15 kN/m <sup>2</sup> |
|                 | Deaerator floor and platform around deaerator                  | : | 10 kN/m <sup>2</sup> |
|                 | Control room   | : | 10 kN/m <sup>2</sup> |
|                 | Battery Rooms  | : | 20 kN/m <sup>2</sup> |
|                 | AHU, AC & Ventilation plant floors                             | : | 10 kN/m <sup>2</sup> |
|                 | PLCC, relay room   | : | 15 kN/m <sup>2</sup> |
|                 | Platform & Stairs  | : | 5 kN/m <sup>2</sup>  |
|                 | Other floors   | : | 10 kN/m <sup>2</sup> |
|                 | Chequered Plate & Grating floors<br>(Including opening covers) | : | 5 kN/ m <sup>2</sup> |
|                 | Precast concrete covers  | : | 12 kN/m <sup>2</sup> |

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**Other Plant Buildings and Areas**

Ground floor/Operating floor	:	15 kN/m <sup>2</sup> or as required by the equipment supplier whichever is higher
Switchgear floor	:	15 kN/m <sup>2</sup>
Stores	:	15 kN/m <sup>2</sup>
Control Room	:	10 kN/m <sup>2</sup>
Stairs and balconies	:	5 kN/sqm
RCC floors, laboratories. Conference rooms and other floors	:	5 kN/m <sup>2</sup>

The above loads are applicable for slabs & secondary beams. 75% of the above load may be considered for design of columns & foundations as it is unlikely that the entire tributary area of the slab will be fully loaded at all levels at the same time.

However, for design of slabs and beams, in addition to the above loads, a live load of 2.5 kN/m<sup>2</sup> and concentrated load of 10 kN at the worst location shall be considered in Operating floor, Switchgear room & Control room to cater for hung loads due to piping and cable trays. Loads due to critical piping shall be taken at actual and checked for local effects.

A minimum UDL of 1.0 kN/sqm shall be considered as Hung loads for ventilation & air conditioning and miscellaneous piping in other floors as applicable.

For areas not covered above and for Non-plant buildings, the relevant loadings furnished in IS:875 (Part 2) shall govern.

**Piping Anchor and Restraint Loads**

Piping load shall be as per load plan drawings unless otherwise mentioned.

Piping anchor and restraint forces of major piping shall be obtained from piping analysis results, and be considered as live load in the structure design.


**Miscellaneous**

Culverts and allied structures including buried RCC Pipes shall be designed for IRC Class "AA" loading and checked for Class 'A' loading.

Covers for trenches & tunnels that are not exposed to vehicular traffic shall be designed for Live Load of adjoining areas or **10 kN/m<sup>2</sup>** whichever is higher. Where trenches / tunnels channels are likely to be exposed to vehicular traffic, the requirements of Code of Practice for Road Bridges shall be adhered to.

For design of walls of basement, trenches, channels etc. below ground, lateral pressure due to a vertical surcharge of 15 kN/m<sup>2</sup> shall be considered in addition to earth and ground water pressure etc. In case of heavy wheel loads, lateral surcharge due to actual wheel loads shall be substituted. When a portion or whole of the adjacent soil is below free water surface, computations shall be based on submerged weight of soil plus full hydrostatic pressure.

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Live Loads reduction shall be in accordance with the provisions of IS : 875 & IS : 1893.

**Crane Loads (CRL)**

Crane girders and supporting columns shall be designed for vertical and horizontal forces (including impact forces) as per crane vendor's data. All lifting beams and monorails shall have their design loads increased for impact factor as mentioned hereinafter.

Loads including impact factor for cranes, hoists and elevators shall be taken as per IS: 875 (Part 2).

**Wind loads (WL)**

Wind load shall be in accordance with IS: 875 (Part-3). The wind shall be assumed to blow in any direction and most unfavorable condition shall be considered.

The external / internal pressure co-efficient shall be as per respective clauses of IS 875 (Part-3)

In design of structures, wind force on equipments supported on frame including all fixtures, piping, staircases, ladders, handrails etc. shall also be considered.

**Seismic load (SL)**

Seismic loads shall be in accordance with IS1893 latest revision covering all parts, corresponding to Zone - III. The following factors as per the code shall be considered to arrive at the seismic loads.

- Zone factor (Z) - 0.16
- Importance factor (I) - 1.75 for power plant buildings  
- (As per provisions of IS:1893, Part I & IV)
- Response Reduction Factor (R) - As per the provisions of IS 1893.

Shear enhancement as per provisions of IS: 1893, Part IV. Seismic analysis shall be carried out by Response Spectrum method for critical structures like GTG/STG building and structures more than one storey high. Single storey buildings / structures may be analysed by equivalent static load method.


Seismic loads for structures not covered in IS: 1893-2002, shall be evaluated based on 1984 version of the code.

Dynamic increment of water pressure and earth pressure due to Seismic Loads shall be evaluated using IS: 1893: 1984 or other relevant Indian / International codes.

**Temperature load**

The structure will be designed to withstand stresses due to fifty percent of the total temperature variation. The total temperature variation for temperature loading should be taken as two thirds (2/3) of the average annual variation in the temperature. The average maximum annual variation for this purpose will be taken as the difference between the mean daily minimum temperature during the coldest month of the year and the mean daily maximum temperature during the hottest month of the year.

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Suitable expansion joints will be provided in the longitudinal direction wherever necessary with provision of twin columns. The maximum distance of the expansion joint will be as per provisions of IS: 800 and IS: 456 for steel and concrete structures respectively.

### Earth Pressure

Earth pressure for design of underground structures shall be based on co-efficient of active earth pressure and earth pressure at rest for cantilever and propped cantilever / two way supported walls respectively.

In addition to earth pressure and ground water pressure etc a minimum surcharge load of 15kN/m<sup>2</sup> shall be considered for all underground structures including channels, sumps, cable trenches etc to take into the account the vehicular traffic in the vicinity of the structure.

### Load Combinations

The individual members of the structures shall be designed for worst combination of forces such as bending moment, axial force, shear force and torsion.

Wind load and Earthquake load shall be assumed not to act simultaneously. The effect of both the forces shall be considered separately in each direction (along and across).

Some of the load combinations to be considered for the design of the main power house are given below.


1. DL + LL + EQUIP
2. DL + LL + EQUIP + Cb + CtLA + CS ± TL +CT
3. DL + LL + EQUIP + Cb + CtLB + CS ± TL+CT
4. DL + EL 1± TL +CT
5. DL + WL1± TL +CT
6. DL + WL2 ± TL +CT
7. 0.75 (DL+0.5 LL + EQUIP+Cb+Ct ±EL2) ± TL +CT
8. 0.75 (DL+ LL + EQUIP+Cb+Ct L1±(CS1 + WL1)) ± TL +CT
9. 0.75 (DL+ LL + EQUIP+Cb+Ct L1±(CS1 + WL2)) ± TL +CT

The following load combinations will be used for getting maximum tension of column base which will be used for the design of holding down bolts.

1. 0.9 DL + 0.9 EQUIP ± EL1
2. 0.9 DL + 0.9 EQUIP ± WL1
3. 0.9 DL + 0.9 EQUIP ± WL2

Notations for above loads are:

- DL - Dead Load of structure, Floors, walls etc
- LL - General Live Load on floors
- EQUIP - Equipment Loads
- Cb - Crane Bridge
- Ct - Crane Trolley positioned at middle of bridge
- CtLA - Crane trolley + Load near one row
- CtLB - Crane trolley + Load near other row
- CtL1 - Crane trolley + Half load lifted at centre of bridge
- CS - Crane surge for full load
- CS1 - Crane surge for half load lifted
- WL1 - Wind load with internal wind co-efficient negative
- WL2 - Wind load with internal wind co-efficient positive

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- EL1 - Earthquake load for DL only
- EL2 - Earthquake load for DL + 0.5 LL
- TL - Temperature load
- CT - Conductor tension load
- SL1 - Seismic Load from left to right
- SL2 - Seismic Load from right to left

**Note**

1. If equipment load is taken at actual, live load of 5 kN/m<sup>2</sup> only shall be considered.
2. Equipment loads shall not be considered as a part of DL for checking the stability of the structure.
3. 0.9 times DL shall be considered for checking stability.
4. Wind load and Seismic load shall be assumed not to act simultaneously. The effect of both the forces shall be considered separately in each direction (transverse and longitudinal).

For buildings with GI sheet roof on structural steel truss & open sides

- DL + IL
- DL + WL1
- DL + WL2

**Underground Structures**

Following loading conditions shall be considered in addition to the loading from super structure for the design of substructure of pump house, channels, sumps, tanks, reservoirs, trenches and other underground structures.

Only liquid pressure from inside and no earth pressure & ground water pressure and surcharge pressure from outside (applicable only to structures which are liable to be filled up with water or any other liquid).

Earth pressure, surcharge pressure and ground water pressure from outside and no water or liquid pressure from inside.

Base slab of the sump shall be designed for the condition of different combinations of pump sumps being empty during maintenance stages with maximum ground water table. Intermediate dividing piers of pump sumps and partition walls in channel be designed considering water on one side only and the other side being empty for maintenance.


**Note :**

- a. Liquid pressure and surcharge load shall include Seismic effects also as applicable.
- b. The underground structures shall be checked for buoyancy due to ground water pressure during construction phase (without superstructure loads).

**Loading Criteria for Pipe and Cable Rack Structures**

**a. Design Loads**

Loads due to self-weight of piping, insulation, valves etc. and the self-weight of structures constitute the Dead Loads. In the absence of exact loading, general uniformly distributed loading as indicated below shall be considered depending on the pipe size and spacing.

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Category	Udl	Equivalent Pipe Size
Light	1.5 kN/m <sup>2</sup>	150 mm dia, schedule 40 @ 250 C/C
Medium	2.0 kN/m <sup>2</sup>	200 mm dia, schedule 30 @ 300 C/C
Heavy	3.0 kN/m <sup>2</sup>	250 mm dia, schedule 20 @ 300 C/C

In case larger size pipes are supported, additional point loads shall be considered in addition to the above loads.

Cable tray loads shall be taken as 100 Kg/m per layer for 600 mm wide tray and proportionately for other sizes. Cable tray supports shall be generally provided at 1.5 m c/c.

The above loads shall be compared with actual piping and cable tray loads and highest loads shall be considered for final design.

The main beams shall be designed to cater for 100% of UDL indicated above, unless intermediate beams are provided, in which case, the load on the main beam can be reduced by 20%.

The intermediate beams and longitudinal beams shall be designed for 25% of UDL, provided pipes are supported only on main beams. In addition the longitudinal beam shall be designed for the reaction from the intermediate beam and concentrated load due to branch / loop pipe above 200 mm dia supported on them.

Unless otherwise specified, friction/temperature loads, shall be taken as 15% of the vertical load and assumed to act on the main beams as UDL, in a direction parallel to the pipes, and perpendicular to the pipes as concentrated load applied at the beam level. Both transverse and longitudinal friction shall be considered together.

Anchor forces shall be as per piping layout and pipe stress analysis. All anchors shall be located on the main transverse beams only.

Wind force acting on the rack frames shall be estimated based on the wind pressure arrived at from the design wind speed and force coefficients for windward frame and shielded frame respectively.

**b. Load Combinations**

The following load combinations shall be considered for Pipe Racks

- DL ± FL ± AL
- DL ± FL ± AL ± WL
- DL ± WL

Where,


- DL = Dead Load
- FL = Friction Load
- AL = Anchor Load

In case Seismic Load (SL) is governing, WL shall be substituted with SL in the above combinations.

**Increase in Allowable Stresses**

Appropriate increase in allowable stresses as per applicable IS Codes shall be considered under wind / seismic loading if design is carried out by Elastic/Working Stress method. If Limit State method of design is used, partial safety factors/load factors shall be applied to the loads as per relevant IS Codes.

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### 5.3.5 Design Criteria - Reinforced Concrete Structures and Foundations

#### General

All structures, building foundations, machines / equipment foundations, water retaining structures, trenches, pits etc. shall be designed as per relevant IS Codes in general.

All designs of RCC structures shall be carried out by limit state method as per IS: 456 unless use of working stress method is specifically mentioned. Design strength of materials and design loads shall be calculated using appropriate partial safety factors over characteristic strength and characteristic loads as per IS: 456. For reinforcement detailing IS: 5525 and SP: 34 shall be followed.

Water Retaining structures shall be designed as uncracked sections by working stress method as per IS : 3370. The walls of liquid retaining structures shall be provided with reinforcement on both faces for sections 200 mm or more, even if not required from design consideration.

#### Increase in Stresses

Where stresses due to wind (or seismic) are combined with those due to other loads, the allowable stresses in concrete and reinforcement steel may be increased by 33.33% in case of working stress design.

Where the bearing pressure on soil due to wind load alone is less than 25% of that due to dead load and imposed load, it may be neglected in design. Where this exceeds 25%, foundation may be so proportioned that the pressure due to combine effect of dead load, imposed load and wind load does not exceed the allowable bearing pressure by more than 25%. When seismic loads are included, the permissible increase in allowable bearing pressure shall be as per IS: 1893. No increase in allowable stress is allowed when DL is alone is combined with wind/seismic load.

Appropriate increase in allowable stresses as per applicable IS Codes shall be considered under wind / seismic loading if design is carried out by Elastic/Working Stress method. If Limit State method of design is used, partial safety factors/load factors shall be applied to the loads as per relevant IS Codes. The above references are only guide lines and not limiting criteria.

#### Foundation

##### a. General


The foundation type and depth shall be decided based on the final soil investigation to be carried out by the EPC Contractor and recommendations based on the same. Minimum depth of foundation shall be 1500 mm below the natural ground level.

Settlement criteria for shallow foundations shall be generally as follows, or more stringent as per specific equipment requirement & differential settlement criteria.

- 25 mm for plant buildings and structures.
- 40 mm for non-plant buildings and structures.
- 150 mm for steel storage tank foundations (floating roof)
- 200 mm for steel storage tank foundations (fixed roof)

Settlement criteria for pile foundation shall be as per IS: 2911.

75 mm thick lean concrete 1:4:8 shall be provided below footings, base slab etc. as mud mat. For water retaining structures mud mat shall be of mix. 1:3:6 and minimum 100 mm in thickness.

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The Factors of safety for stability of foundation and underground structures shall be as per IS: 456 & IS: 3370.

Additional depth of excavation shall be filled up with PCC 1:5:10.

Piles shall be checked for vertical and lateral loads. Vertical load capacity shall be calculated based on soil bearing capacity (as per IS: 2911) and structural capacity. Lateral capacity shall be evaluated based on horizontal sub-grade reaction approach as per IS: 2911. Structural design of pile shall consider the worst loading (minimum vertical load and maximum moment due to design lateral loads or maximum vertical load capacity combined with maximum moment capacity). Structural load capacity of piles shall be evaluated based on limit state method. The structural capacity shall be calculated for working as well as test piles (load factor for test pile shall be equal to the ratio of test load to design load).

**b. Foundations for Vibrating Machinery**

Design of foundations for vibratory Equipment such as GTG, STG, Boiler feed pumps etc. shall be done in accordance with IS:2974 and they shall be isolated from other foundations for vibration control. To avoid resonance, natural frequencies of the foundations shall be kept at least 20% away from the operating frequency and amplitudes shall be kept within the allowable limits specified by the respective equipment manufacturer or in absence of manufacturer's specified value, as specified in the IS Codes/DIN Codes.

The design of machine / equipment foundation shall be as per IS: 456 and IS : 2974.

All block foundations resting on soil shall be analysed considering dynamic properties of soil. The mass of the RCC block shall not be less than the three times the mass of the machine. Dynamic analysis shall be carried out to calculate natural frequencies in all the modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant codes and / or machine manufacturers shall be satisfied. Minimum reinforcement shall be governed by IS: 2974 and IS : 456.

For the foundations supporting minor equipments weighing less than one ton or if the mass of the rotating parts is less than one-hundredth of the mass of the foundation, no dynamic analysis is necessary. However, if such minor equipment is to be supported on building structures, floors etc. suitable vibration isolation shall be provided by means of springs, neoprene pads etc. and such vibration isolation system shall be designed suitably.

All such foundations shall be separated from adjoining part of building and other foundations. Joints at floor / slab shall be suitably sealed. All appendages to such foundations shall be reinforced suitably to ensure integral action.


**c. Foundation for Chimney**

The stability of the foundation as a whole shall be investigated and weight of foundation shall be so proportioned that the least resisting moment shall be not less than 1.5 times the maximum overturning moment due to dead load and wind load / seismic load in shell alone case and 2.0 for the completed chimney. Foundation shall be in the form of rigid mat.

No increase in bearing capacity or in stress shall be allowed for wind loads.

No Loss of contact shall be allowed for the foundation raft for any of the load combinations.

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### Concrete

For structural concrete items, Cement to be used shall be either Portland slag cement with minimum 50 % slag or Portland pozzolana cement since the site is exposed to severe environmental condition due to marine environment,

Additionally if the detailed soil investigation calls for more severe protection, the same shall be considered for construction.

In case of any contradiction between the provisions of cement with any other clause, the requirement specified here in clause no 5.3.5 shall govern.

All structural concrete shall be made dense and nonporous with water cement ratio not exceeding 0.45. Plasticizers shall be used, if required, to maintain the required slump.

The following minimum grades of concrete as per IS: 456 shall be adopted for the type of structures noted against each.

- M20 - Base plate encasement, paving including plinth protection, encasement of structural steel etc.
- M20 - Grade slab, drain, pipe trenches, cable trenches, culverts, roads,
- M25 - All RCC members except where other grades are specified.
- M30 - For GTG, STG, Chimney foundations
- M30 - Piles
- M30 - Precast concrete
- 1:3:6 - Mud mat below tank foundations
- 1:4:8 - Plain Concrete Footing, base slab of drains.
- 1:5:10 - Fill concrete.

However requirement of table 4 & 5 of IS 456 shall be satisfied depending on the exposure condition. As per IS 456, the environmental exposure condition of "severe" shall be considered for design condition.


However requirements as per design mix shall be finally followed for the construction.

Intermixing of grades of concrete in the same structure shall not be allowed in a particular structural element.

All precast slabs for trenches shall be provided with MS edge protection angles on all sides with minimum size as 50x50x6 mm.

The RCC trench edge shall be provided with suitable MS angle for protection. All concrete edges shall be protected with MS angle of size 65x65x6 mm minimum with MS lugs of size 25x6 mm.

Underground structure painting: Irrespective of soil report recommendations, for concrete substructures two coats of ERPB (Epoxide resin based anticorrosive and chemical resistant paint) over a coat of CPCI (concrete penetrating bipolar corrosion inhibitor) shall be applied with 300 to

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325 micron DFT for protection of concrete against carbonation & chloride penetration in saline/marine environment.

IP Net coating system will be applied to the external surfaces of columns, beams, fan deck slabs and all other exposed concrete structure. The total DFT of 370 microns will be applied as per manufactures instructions

**Reinforcements**

TMT/High Yield Strength Deformed steel bars of grade Fe-500 bars conforming to IS-1786. painted with fusion bonded epoxy coating as per IS: 13620 shall be used for reinforcement. Binding wire shall be PVC coated binding wire.

**Minimum Thickness of Structural Elements**

The following minimum thickness shall be followed:


- |    |   |   |                           |
|----|---|---|---------------------------|
| a. | Suspended floor slab / roof slab / walkways / Canopy slabs etc.       | - | 125 mm                    |
| b. | Ground floor slab (non - suspended)                                   | - | 150 mm                    |
| c. | Water Retaining Slab / Walls  | - | 200 mm                    |
| d. | Cable / Pipe Trenches / Underground pit / Launder walls and base slab | - | 150 mm                    |
| e. | All footings (including raft foundations)                             | - | 300 mm                    |
| f. | Tapered footings  | - | 150 mm<br>(Min. at edges) |
| g. | Parapets / Chajjas  | - | 125 mm                    |
| h. | Precast louvers / fins  | - | 50 mm                     |
| i. | Precast trench cover slabs / floor slabs<br>Louvers                   | - | 75 mm                     |
| j. | Precast beams   | - | 150 mm                    |
| k. | Paving  | - | 150 mm                    |
| l. | Basement walls and base slab  | - | 150 mm                    |
| m. | Pilecaps  | - | 300 mm                    |

**Minimum Cover to Reinforcement**

Clear cover to reinforcement shall be as follows:

	Top (mm)	Bottom (mm)	Sides (mm)
Footings (Raft and Isolated)	50	75	50
Pile caps	50	100	50
Grade beam	40	40	40
Grade slab	25	25	25
Columns & Pedestals	50	-	50
Beams above ground level	35	35	35
Lintel beams (Size < 300 x 300)	25	25	25
Block foundation including GTG/STG foundation	50	100	50
Slabs & staircases	25	25	25
Cable trenches			
Base slab	20	35	35
Roof slab	15	35	35
Walls	20	35	35

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Liquid retaining Structures			
Base raft	40	40	40
Side Walls (Water face)	30	-	30
Side Walls (Soil face)	50	-	50
Precast Units	15	25	20
Surface Drains (Base slab and walls)	25	25	25

**Minimum Cover for Foundation Bolts, Base Plates and Pockets**

- a. Clear distance from the edge of the base plate / base frame to the outer edge of the pedestal shall be minimum 50 mm.
- b. Clear distance from the face of pocket to the outer edge of the pedestal / foundation shall be 75 mm.
- c. Clear distance from the edge of the sleeve or anchor plate to the edge of pedestal shall be 75 mm.

**Minimum Heights for Pedestals of Steel Columns**

**Pedestals to Steel columns for building structures**

Top of RCC foundations (pedestals) shall normally be kept at a height of 300 mm above the floor level.

**Other Pedestals and Foundations**

- |      |  |   |  |
|------|--|---|--|
| i.   | Stair and ladder pedestal                  | - | 200 mm above the finished floor level                      |
| ii.  | Equipment in open area                     | - | as required (300 mm min.)                                  |
| iii. | Equipment in covered area                  | - | as required (150 mm min.)                                  |
| iv.  | Structures / equipment supplied by vendors | - | as per vendor's data subject to minimum as specified above |

In case the top of pedestal is kept at a lower level so that the column base plates together with gussets and stiffeners remain below finished floor level (FFL), the column bases as well as column sections shall be encased in concrete above FFL as per following:


- |     |              |   |  |
|-----|--------------|---|--|
| i.  | Open area    | - | 300 mm above FPL/FGL, whichever is higher. |
| ii. | Covered area | - | 150 mm above the finish floor level        |

FPL = Finished Paved Level  
FGL = Finished Grade Level

**Grouting**

Cement mortar (1:1 or 1:2) grout with non-shrink additive shall be used for grouting below base plate of columns. For grouting of base of machine foundation, high strength ready mixed non shrink grout of approved brand (approved by OEM and Owner/Owner's representative) shall be used.

Crushing strength of the grout shall generally be one grade higher than the base concrete. Minimum grade of grout shall be M30.

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Nominal thickness of grouting shall be at least 50 mm for building columns and pedestals of major equipments. For secondary posts, stair and ladder base etc. grouting shall not be less than 25 mm thick.

**Deflection Criteria**

The following deflection criteria shall be considered in sizing of structures as per IS: 456.

- i. The final deflection due to all loads including effects of temperature, creep, and shrinkage, measured from as cast level of the supports of floors, roofs & all other horizontal members shall not exceed span/250.
- ii. The deflection including effects of temperature, creep & shrinkage occurring after erection of partitions and the application of finishes shall not exceed span/350 or 20mm whichever is less.

Under transient wind load the lateral sway at the top should not exceed H/500, where H is the total height of the building.

The maximum horizontal relative displacement due to seismic forces between two successive floors shall not exceed 0.004 times the difference in level between these floors.

**Water Retaining Structures / Basements**

Water Retaining structures shall be designed as uncracked sections by working stress method as per IS: 3370.

Dry basements for which external water proofing is not provided and subjected to ground water pressure from outside may be designed in accordance with the recommendations of IS:456. Crack width shall be restricted to 0.1 mm.

Minimum thickness of structural elements for water retaining structure with two layers of reinforcement shall be 200 mm.

All construction joints in underground structures will be provided with 250 mm wide, 8 mm thick PVC water stop of approved make.

**CW Pump House and Forebay**

The dimensions of the Pump house shall be decided by the Bidder based on Equipment Layout considerations.

Forebay walls shall be designed as counterfort retaining walls. Forebay base shall be provided with pressure relief valves to prevent uplift due to buoyancy effects. The pump house and forebay have to be investigated for necessary factor of safety against uplift during various stages of construction.


**5.3.6 Design Criteria - Steel Structures**

**Framing**

All steel framed structures shall generally be of rigid frame in the generally transverse direction and braced frame in the longitudinal direction with bracing confined to selected bays.

Lateral forces shall be resisted by stiff jointed moment connections in rigid frame design. The column bases shall generally be fixed to concrete pedestal / column by providing moment resistant base detail.

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### Design Methodology

The design of steel structures shall be done by working stress method in accordance with the provisions of IS : 800 and other relevant IS codes as applicable to specific structures.

Crane gantry girders shall be a rolled section with flange plate and or welded construction with bearing and intermediate stiffeners. Crane girder shall be designed as simply supported and of single span length.

Permissible stresses for different members shall be allowed to exceed by 33-1/3% under wind and seismic conditions. However, permissible stresses in bolts and welds shall be allowed to exceed up to 25% only.

For design which requires the use of the minimum column load (such as, uplift on anchor bolts, column axial tension etc.) 90% of Dead Load along with uplift forces if applicable shall be considered.

Base plates shall be placed on foundation pedestal with grouting. For large base plates necessary grout holes shall be provided. Generally anchor bolts for fastening steel columns on foundation shall be embedded in foundation during concreting itself using suitable templates for correct positioning. No anchor pockets in foundation shall be allowed for anchor bolts in tension. Design of base plates shall be based on design pressure on foundation, which shall not exceed the appropriate bearing values given in IS: 456.

The total horizontal shear force at the base of column is transferred to the column pedestals through friction between the base plate and the grout. A co-efficient of friction of 0.30 shall be used in conjunction with the minimum column load, as defined above. If the horizontal shear force exceeds the frictional resistance force shear may be transmitted through bolts or shear keys. If the column is subjected to a net uplift load, the total force shall then be transmitted through shear bars / shear keys welded to the base plate. Necessary recesses shall be kept in the foundation concrete for shear lugs.

Minimum height of the encasing of structural columns shall be 300 mm to 500 mm.

Angle sections shall not be used as flexural members except for roof trusses, purlins, side girts and walkway runners.

For axially loaded members in framework, minimum angle section to be used shall be ISA 50x 50 x 6.


End connections for rolled beams, built-up beams etc. shall be designed for a minimum of 75% of their shear capacity and 100% of moment capacity (for moment connection).

Moments shall be considered for design of columns arising due to eccentricity of floor beam connections with column. Minimum eccentricities on column shall be considered as per IS: 800.

For edge protection around cutouts / openings in floor slabs. Minimum angle section to be used shall be ISA 50 x 50 x 6 with suitable anchor lugs.

Toe guards shall have a minimum depth of 100 mm and a minimum thickness of 6 mm.

Hand railing shall be of hot dip galvanized construction out of 40 mm NB pipes of medium class conforming to IS: 1161 with threaded ends and necessary bends, tees, elbows, sockets etc. Hand railing shall be 1000 mm high with two horizontal rails one at 500 mm and another at 1000 mm above the base level along with vertical posts spaced at not more than 1500 mm centres.

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Where floor beams form part of the vertical bracing system, additional loads from floor beams transferred to bracing shall be taken into consideration in the design.

Minimum width of steel staircase shall be 1000 mm. Minimum width of treads without nosing shall be 250 mm. Maximum height of riser shall be 200 mm and they shall be limited to 16 per flight. Staircases shall be provided with hand railing. Staircase step shall be made out of chequered plate or gratings of presswelded construction designed for a live load of 500 Kg/Sqm.

For any structural steel member, a minimum of 2 nos. 16 mm dia black bolts shall be used for permanent bolted connection and 1 no. 16 mm dia erection bolt for site welded connections.

All foundations bolts shall be provided with one nut and one locknut.

Base plate arrangements of all structural steel columns in buildings shall be so provided that the entire base assembly is below finished floor level. The base plate assembly shall be suitably encased in RCC. For open structures, base plate shall be rest on RCC pedestals, which are 300 mm above finished ground level.

All grouting work below stanchions / bases of equipment shall be with, branded premixed non-shrink free flow grout of approved manufacture which shall have a minimum crushing strength of 450 Kg/cm.Sq. at 28 days.

Minimum thickness of color coated GI sheets to be provided as roofing and cladding shall be 0.5 mm Minimum slope of color coated GI sheet roofs shall be 10 degrees.

**Materials**

Structural steel shall conform to IS : 2062.

Chequered plates shall conform to IS : 3502. Pipes for handrail shall be as per medium grade of IS: 1161. Crane rails and transformer track rails shall conform to IS: 3443.

**Connections**

Generally all shop and field connections shall be welded except for field connections. All moment connections, if bolted shall be of High strength friction grip bolts. Shear and other minor connections, if bolted may be made with mild Steel / High strength bearing bolts.

IS: 816 and IS: 9595 shall be followed for welding of structures. Electrodes of approved makes shall be used.


For high strength friction grip (HSFG) bolt connections, IS: 4000 shall be followed. High strength friction grip bolts shall be of property class 8.8 and shall conform to IS: 3757 and shall not be less than 20 mm in diameter. High strength bolts shall be installed as bearing type joint except where loads are reversible.

All other (other than HSFG) bolted connections shall have bolts of minimum 16 mm dia. The connections of stairs and hand railing shall be made with 16 mm diameter threaded fasteners conforming to IS: 1363. Erection bolts shall be black bolts of minimum 16 mm dia.

All bolts and nuts have property class compatible to each other. Bolts carrying dynamic or fluctuating loads and those in direct tension shall be provided with an additional double coil helical spring washer conforming to IS: 6755.

Where a steel beam or member is to be connected on RCC structure, it shall be connected using an insert plate and preferably through shear connection.

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For crane girders, full penetration of weld between web plate and top flange shall be ensured.

The working point of the bracing connection shall be the centre of column and girder to which it connects, where practical. The connections of gusset plates to column and girders shall be made to include provisions for eccentricity in connection. The double angle back-to-back with gusset plates in between shall not be used in dust-laden areas. Where double angles are not adequate, beam sections with web in the plane of bracing are to be used.

Horizontal bracings shall be angle / tee section located at the bottom of framing beams. Field welding of bracing at the underside of beam as required to meet slenderness requirement of bracing member shall be indicated on the drawings. Horizontal bracing shall be arranged to avoid framing into the beams at columns locations.

Intermittent welding shall not be permitted.

**Permissible Deflections**

The permissible deflection of various steel members under normal loading conditions shall be as specified below. For calculation of deflections in structures and individual members dynamic effects shall not be considered, unless specified otherwise. Also, no increase in deflection limits shall be allowed when wind or seismic loads are acting concurrent with normal loading conditions.

**Vertical Deflection**

Beam and Girders : Span / 325 or 20 mm whichever is lesser.

For crane gantries or any member subjected to working loads, the maximum deflection under dead load and live load excluding impact shall not exceed the following values:

For manually operated cranes & monorails : Span / 500

For EOT Cranes < 5OT : Span / 750

For EOT Cranes > 5OT : Span / 1000

Horizontal deflections

Columns : 1/325 of height


Crane Supporting Columns : 1/1000 of height for horizontal surge load.

The maximum horizontal relative displacement due to seismic forces between two successive floors shall not exceed 0.004 times the difference in level between these floors.

**Minimum Thickness**

The minimum thickness of various components of a structure and hot rolled sections shall be as follows. The minimum thickness of rolled shapes shall mean flange thickness regardless of web thickness. Structural steel members exposed to marked corrosive environment shall be increased suitably in thickness or suitably protected otherwise as per good practice and sound engineering judgment in each instance.

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- |    |  |   |                  |
|----|--|---|------------------|
| a. | Trusses, purlins, girts and bracing  | : | 6 mm             |
| b. | Columns and beams  | : | 8 mm             |
| c. | Gussets  | : | 8 mm             |
| d. | Stiffeners   | : | 8 mm             |
| e. | Base plates  | : | 10 mm & above    |
| f. | Chequered plates   | : | 6 mm o/p & above |
| g. | Grating flats  | : | 5 mm             |
| h. | Minimum thickness of structural members, other than gratings and chequered plate, directly exposed to weather and inaccessible for painting and maintenance shall be | : | 8 mm.            |

**Minimum sizes**

The flange width of purlins supporting roof sheeting and wall cladding shall not be less than 50 mm.

Width of steel rolled section connected to other member shall be at least 50 mm.

**Slenderness and Depth Ratio**

The slenderness ratio of main members in tension, compression or bending shall be in accordance with IS : 800.

The following limiting ratios of depth to span shall be considered as general guide.

- |    |   |      |
|----|---|------|
| a. | Truss   | 1/10 |
| b. | Rolled beams and girders for ordinary floors and rafters    | 1/24 |
| c. | Supporting floor beams for vibrating machinery / equipments | 1/15 |
| d. | Roof purlins and girts                                      | 1/45 |
| e. | Gable columns   | 1/30 |

**Painting and Corrosion Protection Measures**

Structural steel shall be painted after sand blasting as per specification.

For galvanised structures, rate of zinc coating shall be not less than 0.710 kg/m<sup>2</sup>, unless mentioned otherwise.


**5.3.7 Design Criteria for Chimney**

**General**

The Steel Chimney shall be designed for all loads including the weight of chimney, accessories, temperature and wind or earthquake. Due consideration shall be given to loadings during the construction/erection phase and accounted for in the design.

**Dead Load**

All permanent loads due to the weight of chimney shell, platforms, ladders, flue ducts and other accessories.

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**Imposed Load**

Imposed load on service platforms around chimney shall be taken as 300 kg/m<sup>2</sup>. Design live load during construction/erection shall be computed as per actual condition.

Imposed loads from the duct joining the chimney.

**Wind Load**

The wind loading shall conform to IS-875, Part III - 1987. Dynamic analysis shall be carried out as per relevant standards and stability ensured under such condition. If two or more chimneys are spaced at less than 20 times the diameter of bigger chimney at 2/3 of their height or when the chimney is located close to other structure of comparable height, special consideration shall be taken into account for carrying out wind loading analysis due to aerodynamic interference.

**Earthquake Load**

Earthquake forces acting on the chimney and analysis for the same shall be carried out as per IS-1893. The horizontal design seismic coefficient shall be worked out by response spectra method as per IS-1893 with an Importance Factor of 1.75.

**Thermal Effect**

Effect of temperature stresses due to flue gas temperature shall be considered.

**Local Loads**

The effect of following local loads shall also be considered.

- Local moment due to platform.
- Local buckling of shell (For steel chimney).


**Load Combination**

Chimney shall be designed for the most unfavorable load combination during construction, operation and shut down conditions. Various load combinations for calculation of stresses shall be as under.

- a) Dead load + Wind load.
- b) Dead load + Earthquake load.
- c) Dead load + Load due to lining + Imposed load on service platforms + Wind load.
- d) Dead load + Load due to lining + Imposed load on service platform + Earthquake load.

The thickness of lining shall not be assumed to increase the section modulus of the shell nor to resist overturning due to lateral bending action or strutting action from wind/seismic forces for stability checking.

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### Design and Detailing Requirements

Design and construction of various components and systems of the chimney shall be in accordance with the relevant Indian Standards. For provisions not covered in the Indian Standards, reference shall be made to.

Latest editions (except as specified) of Indian and/or other international standards shall be followed for design. Some of the relevant available codes are listed hereunder.

- |          |  |
|----------|--|
| IS: 6533 | Code of Practice for Design and Construction of Steel Chimneys   |
| IS: 800  | Code of practice for use of structural steel in general building construction  |
| ICAO     | International Civil Aviation Organisation (ICAO).  |
| DGCA     | Instructions of Director General of Civil Aviation, India.   |
| BS: 4076 | Specifications for steel chimneys  |
| CICIND   | Model code for concrete chimneys   |
| ASCE     | Design and Construction of steel chimney liners prepared by Task Document committee on steel chimney liners. Fossil power committee (Power division published by ASCE-1975). |

In case of any conflict between this document and the Indian and international standards, the stipulations of this document shall prevail.

Imposed loading for design of all chimney components shall not be less than 5 KN/Sq.m

The chimney and its components shall be designed to resist the most severe forces resulting from all the possible combinations of the various loadings.

All design calculations shall be submitted to the Owner/Owner's representative for approval, and construction work shall commence only after the design has been approved.

### 5.3.8 Design Criteria – Outdoor Facilities


#### Roads

All roads shall be well designed Bitumen Roads. Berms shall be minimum 1m wide and elevated 300 mm above grade level (FGL). Red murrum, minimum 150 mm thick shall be provided for berms. Approach roads to the plant site shall be provided to access from existing road network. Roads as required for plant operation & maintenance inside the proposed plant boundary shall be provided. The layout concept of roads is shown in plot plan. The peripheral roads along the Compound wall shall be of single lane.

The crown of the road shall be minimum 150 mm above FGL. The final finished roads shall have a camber of 1 in 60. Camber on top of compacted crushed stone soling surface shall be 1 in 40.

Wherever drains or other underground facilities cross the roads, concrete pipe culverts of class NP3 or RCC box culverts shall be provided. All culverts carrying storm water shall be cast-in –situ RCC box culverts.

Roads shall be provided with kerb stones and the same shall be painted as per specifications.

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The minimum recommended road section is as follows :

- Sub-base : A layer 300 mm thick coarse sand liner sub-base. Sub base shall consist of stones of 150 mm maximum size in two layers compacted to a thickness of 230 mm.
- Base : 2 layers of Water Bound Macadam (WBM) each 83 mm thick rolled to 150 mm depth.
- Finish
- Semi-grout : 75 mm thick
- Premix carpet : 50 mm thick
- Seal coat : 25 mm thick  
(coarse sand and binder)

(All thickness are compacted thickness)

Initially only water bound macadam surface shall be constructed and after completion of the project but before COD, the damaged portions of the road shall be repaired and the bitumen topping shall be carried out.

The thickness given above is the minimum requirement and it shall be checked and confirmed by the Contractor as per design requirements based on CBR value of the subgrade. All roads should be designed in accordance with IRC 37-2001 for a traffic intensity of 1500 vehicles per day.

**Drainage**

Surface drainage system shall be designed based on maximum rainfall intensity (meteorology report of proposed site area) or 100 mm/hr whichever is maximum. Run-off coefficients for paved areas and unpaved areas shall be assumed to be 0.9 and 0.6 respectively.

A network of open drains shall be provided to carry surface run off which would run along the sides of roads and lead to the nearest natural drain surrounding the plot.

Buildings shall be provided with plinth protection all around, sloped towards side drains. Garland drains shall be provided around all buildings to receive the drainage water from roof and floor connected to the main drains on either side of the roads. 160 mm down take pipes shall be provided for the buildings to carry rain water from roof.

For pipe drains, concrete pipe of class NP2 conforming to IS: 458 shall be used. However for road crossing, class NP3 pipe shall be used. If sufficient clearance cannot be provided between the top of pipe and road top, the pipes shall be encased in RCC.


The maximum velocity of drain shall be limited to 2.4m /sec and 1.8m /sec for pipe drains and open drains respectively. However a minimum self-cleansing velocity shall not be less than 0.6m/sec.

For process drains, catch pits shall be provided at the source locations and they shall be interconnected by buried RCC pipelines and connected to oily water system.

No bends and branches shall be allowed in underground pipes. Where change of direction and/or branches are required manholes shall be provided. Distance between Manholes shall not exceed 30m.

Acid cleaning water shall not be discharged into the storm water drains.

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Interconnection of the drains to the existing system shall be planned at applicable locations

**Sewerage System**

The sanitary sewage system shall be conveyed through underground pipelines by gravity and designed accordingly. Manholes shall be provided at all bends, intersection and in straight stretches more than 30 m long. Sanitary system within the buildings shall be provided as per standards and connected to sanitary disposal system specified elsewhere.

Sewers shall be designed for a minimum self-clearing velocity of 0.75 m / sec. Maximum velocity shall not exceed 2.4 m / sec.

**Effluent treatment System**

A Network of drains consisting of PVC pipes within the buildings and stoneware pipes outside (encased in concrete as required) shall be provided to convey oily water / waste water from the various buildings, transformer outlets, etc. The drains shall discharge into one or more oil water separators. The clear water from the oil water separator shall be let off into the Effluent treatment plant.

**5.3.9 Design Calculations and Drawings**

Detailed design calculations / design drawings shall be commenced by Contractor only after approval is obtained from the Owner/Owner’s representative to the basic design criteria submitted by the Contractor. No deviation from the approved design criteria will be permitted unless specifically approved again by the Owner/Owner’s representative in writing, prior to its adoption.


Civil scope drawings for structural system showing all equipment loads, cut-outs, embedment, etc. based on approved mechanical general arrangement (GA) drawings shall be submitted by the Contractor and these shall be accompanied by detailed design calculations. Drawings and design calculations submitted without prior approval of relevant mechanical GA drawings will not be considered for review.

After the approval of the Contractor’s GA drawings, Owner/Owner’s representative shall identify the structure for which detailed design calculations need to be submitted by the Contractor. Normally, Owner/Owner’s representative shall review and approve design calculations for one typical structure / foundation of each type. However, Owner/Owner’s representative reserves the right to call for design calculations for any additional structure and the Contractor shall have to submit these and obtain Owner/Owner’s representative’s approval. Contractor shall have to ensure that all the balance structures of the system are designed as per the approved designs of typical structures / foundation.

Designs and drawings shall be submitted sequentially in a phased manner and Contractor shall ensure that design calculations / drawings for several structures are not submitted at one time. For this purpose, design / drawing submission schedule shall be furnished by the Contractor for Owner/Owner’s representative’s review and approval. Owner/Owner’s representative will review and furnish comments / approval to the designs and drawings, generally within a period of four weeks from the date of receipt of the same in the Owner/Owner’s representative’s office. Timely submission of designs / drawings to the Owner/Owner’s representative for review / approval is the sole responsibility of the Contractor and postal or other delays as reasons for late / non-submission will not be entertained by the Owner/Owner’s representative.

Designs and drawings submitted by the Contractor shall be thoroughly checked and approved by the Contractor’s authorized engineers before submission for approval. Any unchecked / unsigned documents will not be reviewed by the Owner/Owner’s representative. No claim from the Contractor

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for extension of time or extra cost on this account shall be entertained by the Owner/Owner's representative under any circumstances.

No check will be specifically carried out by the Owner/Owner's representative to verify arithmetical / numerical accuracy of the calculations, which shall remain entirely the Contractor's responsibility.

All design calculations and drawings shall be in English and shall be in SI units.

All modification suggested by the Owner/Owner's representative to meet specification requirements and sound engineering practice shall be incorporated by the Contractor at no extra cost to the Owner/Owner's representative. In this respect, the decision of the Owner/Owner's representative shall be binding on the Contractor.

Should there be a requirement for preparation of separate drawings to show enlarged details to facilitate construction / erection, then such drawings shall also be prepared by the Contractor at no extra cost.

Design drawings showing typical connections and details conforming to design assumptions shall be submitted for approval of the Owner/Owner's representative by the Contractor.

Design drawings for steel structures shall indicate structural arrangement, member size, member forces, splice location, details of base plate, anchor bolts, typical connection details, etc. so that the drawing indicates clearly all the necessary information brought out in relevant design calculations. Proposed bracing patterns shall be subject to approval by Owner/Owner's representative duly considering system requirement point of view. Changes in structural sections on approved drawings shall be got ratified with necessary supporting calculations and reason for the change.

Contractor shall note that all values / dimensions / elevations etc. without supporting break up of data adopted / assumed in his calculations / drawings shall be taken by Owner/Owner's representative to be correct unless these have been specifically indicated in the specification. Any problems later met in this regard shall be made good by the Contractor at his own cost and no extension of time on this ground shall be granted by the Owner/Owner's representative.


The designs shall clearly spell out the erection scheme for various structures envisaged by the Contractor and resulting additional loadings, if any, shall be duly accounted for. Before taking up actual erection work, detailed erection scheme proposed to be followed by the Contractor shall be submitted for Owner/Owner's representative's approval.

Approval / comments conveyed by the Owner/Owner's representative neither relieves the Contractor of his contractual obligations and his total responsibility for correctness of dimensions, materials of constructions, loadings, quantities, design details, assembly fits, performance particulars, safety and stability of the structures including foundations / appurtenances, and conformity of supplies with the statutory laws as may be applicable, nor does it limit the Owner/Owner's representative's right under this contract. No change in the approved designs / drawings shall be permitted without prior written approval of the Owner/Owner's representative.

Preparation of structural steel fabrication drawings is entirely the responsibility of the Contractor.

Detailed civil construction drawings including bar bending schedule for all concrete works shall be prepared by the Contractor and submitted to the Owner/Owner's representative for their review and approval. Construction work at site shall commence only after obtaining written approval to the drawings by the Owner/Owner's representative.

For framed structures, computer analysis shall be adopted and the computer output listing should include all input data covering the design loads and other particulars as specified. The calculations

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shall be supported by all back up documents and references including explanatory sketches and general arrangement drawings.

Computer analysis will be accepted only when the trust worthiness of the program used is established to the satisfaction of the Owner/Owner's representative.

Contractor shall submit typical hand calculations for a few important structural elements to be chosen by the Owner/Owner's representative to validate the computer programs used for the designs.

The Contractor shall submit 2 sets of final calculations/ computer output and 4 sets of drawings and soft copies of design and drawings also for Approval/Stamping by the Owner/Owner's representative and to be distributed after marking 'Approved for Construction' on each drawing. No construction shall proceed at site without 'Approved for Construction' drawings.

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**5.4.0 SPECIFIC TECHNICAL REQUIREMENTS AND FUNCTIONAL REQUIREMENTS**

**5.4.1 Topographical / Contour Survey**

Site is not graded but Earthwork in filling grading/levelling required for the construction shall be done by the Bidder. However Bidder shall carry out the same before carrying out engineering activities with no cost liability on the Owner/Owner’s representative and the same shall be submitted for the approval of Owner/Owner’s representative.

**5.4.2 Geo-Technical Investigation**

Preliminary Soil Investigation has been carried out near the Power Plant Area premises. Copy of the same is attached to the tender. This is intended to give an idea of the soil conditions prevailing at site. However, a detailed Soil Investigation shall be carried out by the Contractor to verify the data provided and to finalise the foundation concept and type of foundations for design work and the report shall be submitted to the Owner/Owner’s representative for approval and the approval report shall become the basis for the design. Any variation in soil conditions and foundation parameters from those indicated in tender documents shall be incorporated in the final design without any cost or time implication. If the soil stratum requires pile foundation, the same shall be done by Bidder without any extra cost.

The investigation shall cover sufficient no. of bore holes in each area to get a longitudinal section of the soil profile, cone penetration tests and laboratory tests to obtain the engineering properties of soil including dynamic properties for areas where GTG, STG, Boiler Feed Pumps etc are to be located. Wherever the structures are to be supported on piles, the boreholes shall extend upto hard rock. The investigation and report shall be in line with the technical specification for soil investigation covered in Clause 5.5.0.

**5.4.3 Fencing**

The CI 6.1.3 of General Technical Specification shall be followed for the areas to be considered for fencing.

**5.4.4 Site Grading**

The area shall be suitably cut and filled to suit the layout requirement.


Fill if any shall normally be made up of Cohesive Non swelling material capable of being compacted upto 95% Modified Proctor density. Filling may also be made using dredged sand in which case a relative density of 85% shall be achieved. In case earth has to be borrowed from outside the plant boundary, the same shall be arranged by the Contractor himself. Earth from Swamps, marshy as well as logs, expansive type of clays, peats, organic material, material susceptible for combustion, material which will react with other material already used in work shall not be used as borrow material.

**5.4.5 Roads & Paving**

**Roads**

The details of the road network shall be in line with the plot plan with the suitable integration with the existing road layout of the Power plant. The arrangement shall be as specified in the CI 6.1.3 of General Technical Specification. For the details of the design and construction Design criteria of roads shall be considered.(refer CI 5.3.8).

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### Paving

HRSG area shall be paved with RCC slab, 150 mm thick in grade M20. 230 mm thick rubble soling shall be provided below the paving. Higher thickness as per design shall be provided in areas of vehicular movement. Top of paving shall be kept 100 mm below FFL. All pavings shall be RCC, no PCC paving is allowed.

#### 5.4.6 Pre constructional Anti termite treatment

Pre-constructional anti termite treatment shall be given to all vulnerable areas susceptible to termite attack and shall include column pits, wall trenches, foundations filling bellow the floors etc. as per IS : 6313 and other relevant Indian Standards.

#### 5.4.7 Underground structures painting

Irrespective of soil report recommendations, For all concrete substructures two coats of ERPB (Epoxy resin based anticorrosive and chemical resistant paint) over a coat of CPCI (concrete penetrating bipolar corrosion inhibitor) shall be applied with 300 to 325 micron DFT for protection of concrete against carbonation & chloride penetration in saline/marine environment.

IP Net coating system will be applied to the external surfaces of columns, beams, fan deck slabs and all other exposed concrete structure. The total DFT of 370 microns will be applied as per manufactures instructions.

#### 5.4.8 Construction Facilities

##### Construction Water & Power

For the provision of Construction water and Power **Clause 5.18** of “**General condition of contract**” shall be referred.

##### Site office and other facilities


Limited ware house and godown facility shall be given to the Contractor. However he has to make his own arrangement for additional requirements like site office, quality control laboratory, stores and other facilities in the available space. Contractor shall construct the above buildings and facilities at his own cost. Temporary construction shall be adopted so that these buildings can be demolished after commissioning of project.

Necessary temporary roads shall also be constructed by the Contractor. The quality control laboratory shall have facilities for testing all construction materials and other necessary tests to ensure field quality control.

All amenities to Contractor's workers, such as canteens, toilets, drinking water, rest places, creche shall be provided by the Contractor.

#### 5.4.9 Architectural and Finishing Requirements

Reference shall be made to **Clause 5.3.2** for specification/thickness of the various Architectural finishes indicated below:

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**Floor Finishes**

- Ground Floor (of all plant buildings) - Indian Patent Stone (IPS) with non-metallic hardener topping
- Switchgear rooms,
- Operating floors
- Control room - Polished vitrified ceramic tiles- 600x600x10 thk
- Battery room - Acid resistance tile flooring, dado and ceiling
- Offices - Polished vitrified tiles of 600x600x10 thk
- Toilet - Ceramic Tiles and skirting with 400x200x6 mm thk
- Oil, Acid & Alkali- spillage areas - Acid / Alkali & Resistant tiles
- General circulation areas like lift, Entrance area, office areas and Laboratories - Heavy duty vitrified ceramic tiles- 600x600x10 thk
- RCC staircases - Granite-20 mm thick black colour premium quality
- Non-Plant Buildings :
- Passages and lobby - Heavy duty vitrified ceramic tiles- 600x600x10 thk
- Other Areas - Heavy duty vitrified ceramic tiles- 600x600x10 thk
- All Pump houses, DG and compressor house - IPS with metallic floor hardener

**False Ceiling**

- Control room and other office areas - LUXALON


**Roof finishes**

- All Buildings - Polymeric membrane based waterproofing

**Joinery**


**- Windows**

- Turbine / Generator bay - Glazed, openable windows with aluminium frame
- Control room - Glazed, fixed windows with aluminium frame with double glazing for outer windows and windows facing turbine bay and with single glazing for internal windows / partition
- Switchgear room - Glazed, fixed windows with Aluminium frame
- Offices - Glazed, openable windows with Aluminium frame

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Other buildings	-	Glazed openable / fixed windows with Aluminium frame
<b>- Doors</b>		
Control room	-	Fully glazed doors with aluminium frame
Offices	-	Fully glazed doors with aluminium frame
Toilets	-	Timber panelled doors with Teakwood frame and marine board panel with laminated plastic sheet on the inside face.
All other doors in Plant Buildings	-	Double plated steel doors
Fire barrier doors	-	Specially designed double plated steel doors with insulation having 2 hours fire rating.
Non plant buildings	-	Timber flush doors with teak wood frame or Fully glazed doors with Aluminium frame.
<b>- Painting</b>		
Structural steel	-	Primer coat- Epoxy resin based zinc phosphate of DFT 100 microns thickness
	-	Intermediate coat- Epoxy resin based paint pigmented with Titanium dioxide of DFT 100 microns thickness
	-	Top coat-epoxy paint suitably pigmented of approved color and shade with glossy finish of 75 microns thick with finishing coat of polyurethane of 25 microns thick
All steel doors/windows/ventilators	-	Epoxy based paint of 250 mm microns thickness
Timber Joinery	-	Synthetic enamel paint
All Ceiling	-	Oil bound distemper (office rooms without false ceiling)
	-	Acid resistant resin based Epoxy coating over two coats of DECKURDS-S manufactured by FOSROC or equivalent (Battery rooms)
		White washing (all other areas)
Internal wall surfaces :		
All areas (except following areas)	-	Epoxy based paint of 250 microns thickness
Control room/office/A/C areas	-	Acrylic Emulsion
External faces of walls equivalent	-	Apex Ultima/Exterior weather shield from ICI or equivalent

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Walls of battery room and other acid/alkali spillage areas

- Chlorinated rubber paint an exposed walls above Dado.

- 2100 mm high Dado of Acid / Alkali resistant tiling

**Metal Cladding**

STG & GTG Building insulated metal cladding system

- Double skin permanent colour coated sandwiched

Other buildings (Where metal claddings is Specified)

- Single skin permanent colour coated (non-insulated) metal cladding system

A standard colour scheme for the different buildings/structures shall be prepared by the Contractor and the approval of the Owner/Owner's representative shall be obtained, before commencement of work.

**5.4.10 Gas Turbine Generator (GTG) / Steam Turbine Generator (STG) Building**

GTG / STG building shall be steel framed building with rigid jointed portal frames in the transverse direction and pin jointed braced frames in the longitudinal direction. TG bay shall have double skin colour coated sandwiched insulated cladding for roof and walls.

The building shall have double skin colour coated sandwiched insulated cladding for roof and walls. Walls have 230 thick brick cladding upto 1.0 metres from floor level and double skin insulated metal cladding above.

One row of continuous windows shall be provided at ground level and above crane girder. The ground floor slab shall be designed to withstand heavy vehicle movement. Suitable floor drainage arrangement with drain pits and buried pipes shall be provided and the same shall be connected to only water system.

**5.4.11 Gas Turbine Foundation Steam Turbine Foundation and Other Equipment Foundations**

**STG Foundation**

The Contractor shall choose between the following two types of foundation systems based on techno- economic considerations. The type of foundation offered shall be indicated in the bid document.


- a) Conventional framed foundation in RCC, isolated from other structures of Power House.
- b) Spring mounted foundation with inertia block supported on RCC structure isolated from the building frame.

Block type foundation may be adopted depending on the type of machine offered by the Contractor.

**GTG Foundation**

The Gas Turbine Generator foundation shall be a rigid mat foundation.

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The Contractor shall furnish detailed calculations containing loading data (static and dynamic), general arrangement drawings and detailed dynamic analysis (free and forced vibration analysis) for Owner/Owner's representative's approval. The model considered for analysis shall take into account pile/soil/structure interaction.

**Other Equipment Foundations**

Foundations for other major equipment such as HRSGs, Boiler feed pump etc. shall also be supported on piles to avoid differential settlement. Type of foundation for other equipment foundation shall be based on the recommendations of the final soil investigation report. Spring supported foundations shall be provided for low frequency machine foundations wherever the same are required from technical considerations. Dynamic analysis calculations shall be submitted for approval.

All the machine foundation structural components shall be tested for voids using Non destructive (NDT) methods as per the recommendations of IS: 13311/UPSV tests, as required by the Owner/Owner's representative.

**5.4.12 Transformer Yard**


Heavy Transformer foundations such as Generator Transformers, Unit auxiliary transformers / Station transformers / Inter Connecting Transformers shall be founded on piles/isolated spread footings depending on the final soil investigation report. Individual transformer foundations shall have its own pit which would cover the area of the transformer and cooler banks, so as to collect any spillage of oil or oil drainage in case of emergency. The oil pit shall be filled with granite stones of 40 mm size uniformly graded. The individual oil pits shall be connected to an oil collection pit which shall be sized to accommodate oil volume of the largest transformer connected to it, without backflow. The oil pit shall be connected to oily water drainage system. Dimensions of the discharge pipe shall consider rainfall intensity also. The water shall be discharged into the nearest drain by gravity flow or pumping.

Provision of fire protection walls shall be provided in between transformer unit for safety point of view.

Local rail track shall be provided from the nearest road for movement of the generator transformers to the foundation location. Rail track foundation shall incorporate jacking pad foundation at intersections of rail racks. Pulling hooks shall be provided at suitable locations for pulling the transformer over the rails.

The area around the transformer shall be provided with RCC grade slab with nominal reinforcement and galvanised chain link fence with fence posts and gates shall be provided. The portion of the fence covering the rail track shall be made of removable type for movement of transformer during erection /removal. Alternatively, gate with provision for locking shall be provided. For small transformers of width not exceeding 5 metres, a gate shall be provided for access of transformer. In addition a small gate, 1.2 m wide shall be provided for man entry. The gates shall have provision for locking.

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#### 5.4.13 Local Electrical/Control Rooms

The dimensions of the buildings shall be decided by the Contractor from Equipment Layout considerations.

Local Electrical / Control rooms for DM Plant and CW pump etc. shall be of RCC construction with plastered brick cladding. Windows and doors shall be of fully glazed type with aluminium box frames. Control rooms will be air conditioned and shall have false floor (where no cable cellar is provided) and false ceiling. In electrical rooms, rolling shutters shall be provided for equipment entry. Electrical rooms and control rooms in upper floors shall have provision for lifting of panels and the equipment access door shall be suitably sized to accommodate the largest transportation module of panels. Cable trenches shall be of RCC construction and with pre-cast RCC covers, where no panels are located. Where panels are located, chequered plate cover shall be provided over the balance width not occupied by panels. Sufficient slope shall be provided in the base slab of cable trenches to drain out seepage water/floor wash water. A sump shall be provided in the deepest stretch of trench and the drains shall be sloped towards the sump. The sump shall be connected to the nearest drain by gravity flow (if possible) or by pumping. Wherever the cable trenches inside the building join with or are continuous with external yard trenches a barrier RCC wall shall be provided at the periphery of the building and pipe sleeves shall be provided in the wall for cable entry. The annular space between the pipe sleeve and the cables shall be sealed after erection of cables.

Sufficient office space and toilet facilities shall be provided for operating personnel.

#### 5.4.14 Chimney

A single flue self supporting Steel chimney shall be provided for one HRSG. The details & heights given are tentative and contractor shall submit calculation to satisfy that provision of Pollution Control Board are met.

External ladders with safety cage for the entire height with landings at every 15m shall be provided. All exposed structural steel items shall be galvanised/painted.

The roofing panels of the platforms and risers of the staircase shall be of gratings construction 25TH. Handrails for platforms and staircase shall be of tubular construction with 40 NB medium tubes.

Painting of steel surfaces shall be carried out as per specification

Necessary aviation day warning shall be provided by way of orange & white bands as per requirement of aviation authorities.


Galvanised mild steel discrete strakes shall be provided at the top (usually 1/3rd height) if found necessary from design requirements.

The superstructure shall be supported on a foundation system with piles.

#### 5.4.15 Water Treatment Plant

All the facilities required for the Water treatment plant like Filtration plant, DM plant shall be housed in a common facility with foundation arrangements for miscellaneous tanks, pumps etc. which are the part of the Water treatment plant. The entire area shall be suitably paved.

Acid/Alkali storage shall be separated with a kerb and the flooring shall be lined with acid / alkali resistant tiles. The drains from the exchangers and vessels discharging into the neutralisation pit

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shall be lined with acid/alkali resisting tiles. Neutralisation pit shall be designed as a water retaining structure with external polymeric membrane based water proofing and internal lining with acid / alkali resistant brick lining. The discharge from the neutralisation pit shall be pumped to Guard pond.

DM Water tanks located outside shall be supported on sand pads with ring wall. The foundation system chosen shall limit the differential settlements.

Suitable maintenance area shall be provided for the water treatment plant.

All the drains in the water treatment plant area shall be provided with FRP grating material.

#### 5.4.16 GIS control Room

GIS Control room shall be of RCC construction with plastered brick cladding. Windows and doors shall be of fully glazed type with aluminium box frames. Control rooms will be air conditioned. In electrical rooms, rolling shutters shall be provided for equipment entry. Electrical rooms and control rooms in upper floors shall have provision for lifting of panels and the equipment access door shall be suitably sized to accommodate the largest transportation module of panels. Cable trenches shall be of RCC construction and with pre-cast RCC covers, where no panels are located. Where panels are located, chequered plate cover shall be provided over the balance width not occupied by panels. Sufficient slope shall be provided in the base slab of cable trenches to drain out seepage water/floor wash water. A sump shall be provided in the deepest stretch of trench and the drains shall be sloped towards the sump. The sump shall be connected to the nearest drain by gravity flow (if possible) or by pumping. Wherever the cable trenches inside the building join with or are continuous with external yard trenches a barrier RCC wall shall be provided at the periphery of the building and pipe sleeves shall be provided in the wall for cable entry. The annular space between the pipe sleeve and the cables shall be sealed after erection of cables.

Sufficient office space and toilet facilities shall be provided for operating personnel.

#### 5.4.17 Pipe/Cable Racks & Trenches


Pipe / Cable Rack shall be of Steel Construction and shall be single / multi-tiered as required. The cable tray supports shall be provided above the topmost pipe tier. Minimum clearance to the lowest tier of pipe rack shall be 3.0 m in general and 9.0 m under road crossings. In between pipes below pipes shall be finished with concrete flooring.

Pipe / Cable trenches shall be of RCC Construction with precast RCC cover slabs. The trenches shall have cross slope and longitudinal slope and shall be connected to drain pits at maximum 100 metre intervals. The drain pits shall have provision for fixing mobile submersible pumps.

#### 5.4.18 CW System

CW Pump houses shall house the cooling water pumps as well as ACW pump for GTG and STG auxiliaries. Necessary forebay and sump accommodating the coarse screen, stop-logs including the handling arrangements shall also be provided in the CW Pump house. Super structure of pump house shall be of Structural steel truss resting on RCC column. No side cladding for CW pump house.

The Mechanical Induced draft cooling tower shall be of RCC framed structure with outside protection of concrete shall be done by use of concrete penetrating silane/siloxane water repelling primer and compatible epoxy top coat with crack bridging ability. DFT of epoxy coating shall be 300 microns. Alternatively, polyurethane based paint system may be adopted with the approval of the Owner/Owner's representative.

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CW channel shall be covered with RC slabs. Precast slabs shall be given at regular intervals for purpose of inspection and maintenance.

Protection of concrete and reinforcement steel against corrosion shall be provided. This shall include use of dense and durable concrete with plasticizer cum water proofing agent, use of sulphate resistant cement, corrosion resistant steel reinforcement, etc.

**5.4.19 Black start cum Emergency DG Shed**

DG shed shall be of Structural steel shed supporting on RCC column with plastered brick cladding all round. Windows and doors shall be of fully glazed type with aluminium box frames. Rolling shutters shall be provided for equipment entry.

**5.4.20 Compressor House cum workshop**

The dimensions of the buildings shall be decided by the Contractor from Equipment Layout considerations.

Compressor house cum workshop shall be of Structural steel shed with side sheeting all round.

Rolling shutters shall be provided for equipment entry. Compressor house shall have provision for lifting of panels and the equipment access door shall be suitably sized to accommodate the largest transportation module. Cable trenches shall be of RCC construction and with pre-cast RCC covers, where no panels are located. Where panels are located, chequered plate cover shall be provided over the balance width not occupied by panels. Sufficient slope shall be provided in the base slab of cable trenches to drain out seepage water/floor wash water. A sump shall be provided in the deepest stretch of trench and the drains shall be sloped towards the sump. The sump shall be connected to the nearest drain by gravity flow (if possible) or by pumping. Wherever the cable trenches inside the building join with or are continuous with external trenches a barrier RCC wall shall be provided at the periphery of the building and pipe sleeves shall be provided in the wall for cable entry. The annular space between the pipe sleeve and the cables shall be sealed after erection of cables.

**5.4.21 Misc. Plant Buildings**

All miscellaneous plant buildings shall be of RCC construction with brick cladding. Glazed steel windows and steel plated doors shall be provided.

**5.5.0 Standard Technical Specification for Construction**

**5.5.1 Soil Investigation**


**Scope**

This specification describes the methods and procedures for soil boring, field and laboratory testing of soil samples. It also outlines the contents of the soil report.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship and methods & procedures of testing. Some of the relevant available codes are listed here under.

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- IS: 446 Presentation of drilling information and core description in foundation investigation.
- IS:1498 Classification and identification of soils for general engineering purposes
- IS: 1888 Method of load tests on soils
- IS: 1892 Code of practice for sub-surface investigation for foundations
- IS: 2131 Method of standard penetration test for soils
- IS: 2132 Code of practice for thin-walled tube sampling of soils
- IS: 2720 Methods of test for soils (ALL PARTS)
- IS: 2809 Glossary of terms and symbols relating to soil engineering
- IS: 2810 Glossary of terms and symbols relating to soil dynamics
- IS: 4078 Indexing and storing of drill cores.
- IS: 4968 Method of sub-surface sounding for (ALL PARTS) soils
- IS: 5249 Method of test for determination of in-situ dynamic properties of soils
- IS: 5529 Code of practice for in-situ permeability tests
- IS: 9214 Method of determination of modules of subgrade reaction (k-value) of soils in field
- IS: 10060 Code of practice for subsurface investigation for power house sites

In the event of any conflict between the requirements in the specification and the above referred codes, the former shall govern.

**Equipment and Personnel**


The Contractor shall ensure that all machinery, equipment, instruments, etc., mobilized by him at site are in proper working order and accurately calibrated. If necessary, the Contractor shall obtain from independent and approved testing laboratories such reports/ certification as the Owner/Owner's representative may require to satisfy himself about the reliability of the Contractor's machinery, equipment, instruments, etc. The Contractor shall ensure that the field investigation and laboratory work are performed by competent technical personnel and labour who are specifically qualified and experienced in soil investigation work.

Interpretation and recommendation shall be the direct responsibility of the experienced senior technical personnel in the Contractor's organisation.

**Setting Out**

The Contractor shall be responsible to perform the necessary survey work to locate the bore holes/test locations on ground and obtain the ground levels at these locations with respect to the grids and bench mark provided by the Owner/Owner's representative.

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### Boring through Soil

The method and diameter of boring shall be approved by Owner/Owner's representative. Minimum diameter of bore hole shall be 150 mm. Uncased holes are permitted only up to a depth where the side can stand unsupported. In case of side fall is noticed, the holes shall be stabilized immediately by using bentonite slurry or providing casing pipes as directed by the Owner/Owner's representative.

Water shall not be added while boring above water table level. Mud circulation/bentonite slurry shall not be used in the bore holes from which water sample is to be collected for analysis.

Casing pipes, where used, shall be stopped 150 mm short of the bottom of the bore at any stage of boring, particularly before collection of undisturbed samples or before conducting Standard Penetration Tests.

Bore holes shall generally be sunk up to the hard stratum or to a depth of 25 m below the ground level whichever is earlier, unless otherwise instructed by the Owner/Owner's representative. Drilling must be continued into rock or hard stratum having SPT value more than 75 for at least two bore holes. If rock/hard stratum having SPT value more than 75 is met with at a shallower depth, it shall be ensured that it is really the rock/hard stratum by continuing the boring into the stratum by 3m. Drilling in rock shall be carried out by rotary core drilling described under Rock Drilling.

The Contractor shall send copies of daily boring records to Owner/Owner's representative at the end of each day. These records shall include the field observations with regard to visual description of soil strata, level of ground water table, drilling fluid consumption, presence of lime, mica, etc. Bore holes shall be backfilled with bentonite/mud cement grout after all samples and other information are obtained from the bore holes.

### Rock Drilling


During boring operation, once the rock strata is encountered, the normal method of boring operation as described earlier shall have to be stopped and drilling operation shall be resorted to for determining depth and nature of rock strata, in a manner as described below.

Rotary core drilling technique with continuous core recovery should be adopted for drilling through rock. The behaviour of rock mass is governed more significantly by the nature of fractures in the rock than by the type and hardness of the material composing the rock itself. Hence, good drilling technique should be adopted to obtain an intact sample truly representative of the in-situ material and for achieving highest percentage of recovery possible.

Variations in the speed of rotation, the downward pressure on the core barrel, the pressure at which the drilling fluid is introduced into the hole and the length of hole drilled (run length) prior to removal of the core are major items which must be controlled by the driller. In general, coring should be initiated with short runs because the upper portions of rock masses are commonly highly fractured and also because the elevations of any core losses can be more accurately determined. If conditions indicate that it is possible, the length of the runs may be determined by the length of the core barrel.

In zones which are highly fractured or where the barrel continuously becomes blocked, it is essential that short runs be used even though this means removal of the entire string of drilling tools every 300 mm. or less. Reduced bit pressure should be resorted to when rod vibration or chatter occurs. The pressure under which the drilling fluid should be introduced into the hole shall be the minimum to be consistent with adequate removal of cuttings from the hole and proper cooling of the bit. To minimize the erosive action of the drilling fluid on the core and thereby to improve core recovery, double tube core barrels should be used. The casing and core barrel to be used shall be of designation BX or NX.

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During the drilling operation for each bore hole the Contractor shall record the rate of sinking of drill rods, ground water table elevations, if any, nature, type and sequence of rock drilled. From the recovered cores, the Contractor shall determine nature of fractures and degree of weathering of the rock for each bore hole. The Contractor shall also note and record any appreciable loss of drilling fluid throughout the entire drilling operations for each bore hole. The Contractor shall also determine the percentage recovery ratio and rock quality designation from the recovered cores for each stage of core advance and for all the bore holes.

The Contractor shall furnish all the information mentioned above fully verified and signed by the Owner/Owner's representative at site and submit them in triplicate to the Owner/Owner's representative.

The drilling operation shall be terminated either 3 metres in hard rock or 95% of core recovery whichever is later.

In addition to the above mentioned points, the Contractor shall also take into consideration the provisions of the latest revisions of the relevant BIS Codes of Practice along with Amendments, if any.

**Collection of Samples**

**Sampling Depths**

Soil samples shall be taken generally at intervals of 1.5m and each change of strata in bore holes. Disturbed and undisturbed samples, wherever possible shall be collected. All samples collected shall be suitably and uniquely labelled.

**Undisturbed Soil Samples**

Soil samplers shall conform to relevant Indian standards. Undisturbed samples shall be 90 mm in diameter and 450 mm long. The type of sampler shall be appropriate for the soil to be collected. The undisturbed samples need not be collected when the SPT value is greater than 50.

All care shall be exercised by the Contractor not to disturb the soil during sampling operation. The sampler shall be forced in one continuous motion, not driven, into the ground below the casing. The sample shall be shipped to the laboratory in such a manner as not to cause any disturbances to or loss of moisture from the sample. The soil sample shall not be removed from the sampler tube and the ends shall be filled with paraffin and sealed with metal/ plastic caps. The Contractor shall have, at site, adequate number of samplers at all times.


**Disturbed Soil Samples**

Disturbed soil samples shall be collected from thin walled samplers or split spoon samplers of SPT. The samples shall be collected in air tight jars.

**Ground Water Sample**

Ground water sample shall be collected from any three of the bore holes. Care shall be taken to ensure that no other extraneous water, slurry or storm water, etc., gets mixed with natural ground water in the bore hole before collection. One litre of ground water shall be collected in clean and air tight container to be sent to the laboratory for immediate testing.

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**Trial Pits**

Trial pits shall be of minimum 3 m. x 3 m. size at base so as to permit easy access for a visual examination of the walls of the pit and to facilitate sampling and in-situ testing operating. Precautions shall be taken to ensure the stability of pit wall, if necessary even by the provision of shoring. Arrangements shall be made for dewatering if the pit is extended below water table. In-situ tests shall be conducted and undisturbed samples obtained immediately on reaching the specified depths, so as to avoid substantial moisture changes in the subsoil.

After completion of tests and examination, the pits shall be suitably backfilled as directed by the Owner/Owner’s representative. Unless specified otherwise, the excavated soil shall be used for this purpose.

**Standard Penetration Test (SPT)**

The equipment and procedure for Standard Penetration Test shall conform to IS: 2131. The bottom of bore hole shall be cleaned of mud slurry before conducting the Standard Penetration Test (SPT). The SPT shall be conducted generally at 1.5 m intervals and at changes of soil strata, as per IS: 2131. The blow count shall be recorded. If the blow count exceeds 75 or if the penetration is less than 25 mm per 50 blows, the test shall be stopped.

**Static Cone Penetration Test**

The test equipment and procedure shall meet the requirements of IS: 4968 (Part III). This test shall not be carried out on gravelly soils and for soils having SPT value greater than 50. The capacity of the equipment to be used for test shall not be less than 3.0 tonnes but preferably 10.0 tonnes. The cone resistance and cone & friction resistance shall be measured at pre-determined intervals. The rate of pushing shall be 1 cm per second. Unless otherwise specified it shall be conducted up to a depth of 25 m. If the penetration is found to be difficult at a shallower depth due to occurrence of fragment of rock or boulder the test shall be terminated and be executed at adjacent location as directed by the Owner/Owner’s representative.

The results shall be prescribed in graphical form as well as in tabular form as given in Appendix-A of IS: 4968 (Part III).

The Contractor shall carefully interpret the results of boring and sounding.

**Dynamic Cone Penetration Test**


The test equipment and procedure shall meet the requirement of IS: 4968 (Part II). The driving shall not be done for more than 30 cm at a time after which it shall be stopped for a minute or two. Pumping shall, however, be continued. The tests shall be terminated when the blow counts exceed 35 for 100 mm. penetration when the cone is dry and 20 for 100 mm. penetration when the cone is penetrated by circulating slurry.

The results shall be reported in a suitable tabular form giving blow counts for every 30 cm. penetration supplemented by a graphical plot of blow count versus depth.

**Plate Load Test**

Plate load tests shall be conducted at the specified founding depth by making test pit of sufficient size as per IS: 1888. Side protection, if required, shall also be provided by the Contractor at no extra cost. The Contractor shall provide suitable access to the bottom of the pit. The load shall be applied to the plate by hydraulic jack of suitable capacity jacking against a fixed platform loaded with sand bags or heavy truss anchored in the ground. The increment of each loading shall be such that the

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ultimate load is reached in not less than ten increments. The water table level shall be noted in the nearest bore hole at the time of testing. If water table is within test zone to a depth of 3 times the width of plate, it is advisable to conduct the test at higher level.

The pit shall be backfilled with excavated earth in layers not exceeding 300 mm and well compacted.

**Cyclic Plate Load Tests**

The equipment and set up for cyclic plate test shall be similar to plate load test described above. The testing procedure shall be as per IS: 5249. The duration of each loading and unloading cycle shall be decided based on the type of soil under investigation. The initial loading and unloading cycles up to the safe bearing capacity of soil should be with smaller increments in load. The magnitude of load increment should be such that the ultimate load is reached in five to six increments. Based on the above test, the Contractor shall recommend the coefficient of sub- grade reaction, coefficient of elastic uniform compression.

**Vane Shear Test**

The test shall be conducted in soft to firm clays and sensitive clays. The test shall also be conducted in case of stiff fissured clays where samples cannot be taken. Tests may also be conducted by direct penetration from ground surface. The equipment used for vane shear tests shall be as per IS: 4434.

Straightness of vane shall be checked while the entire assembly of vane connected with the rod is being lowered to the bottom of bore holes. Samples shall be collected from the levels at which the tests have been conducted.

The results shall be reported in a suitable tabular form.

**In-Situ Permeability**

In-situ permeability test shall be performed in the bore holes specified or as directed by the Owner/Owner's representative for the determination of the permeability coefficient of the soil. The tests shall be conducted as per IS : 5529 (Part I) using pumping out method with piezometer installations.

**Menard Pressure Meter Test**


This test shall be carried out as per IS : 1892 to the full depth of bore holes, to assess the coefficient of earth pressure at rest and the stress-strain modules of soil. The tests shall be carried out at every 3.0 m. intervals.

The Contractor shall submit, for approval of the Owner/Owner's representative, detailed arrangement drawings for the tests including the detail of the equipment proposed.

**Block Vibration Test**

In-situ dynamic properties of the soil shall be determined by performing Block vibration tests in accordance with IS: 5249 at the location and depth indicated. A plain concrete block in concrete grade M 15 and of size 1500 x 750 x 700 mm shall be cast, at the specified founding depth for machine foundations. The test pit should be of suitable size having sufficient clearance for conducting the test. Forced vibration and free vibration tests shall be conducted. The wave propagation test for determination of shear modules shall also be conducted by exciting the block to the steady state vibrations in the vertical direction. The block shall have suitable provisions to fix the oscillator in different modes and at different frequencies. By suitable and adequate instrumentation,

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the soil responses to the excitation are measured and various dynamic properties are computed. Based on these tests, the Contractor shall recommend design values to be adopted in design. Before backfilling the pit, the concrete block shall be dismantled and disintegrated and all rubbish shall be disposed off as directed by the Owner/Owner's representative.

### Electrical Resistivity

Electrical Resistivity of subsurface layers shall be determined by vertical electrical soundings by Wenner's method as indicated in IS: 1892. The spacing between the electrodes is initially kept as 0.5 metres and then gradually increased in steps of 0.5 metres up to 5.0 metres depth. Graphical representation of resistivity versus depth shall be plotted.

### Laboratory Tests

All laboratory tests to assess the engineering properties of soil/rock shall be conducted by the Contractor in an approved laboratory. It is not the intent nor is it practical to specify all technical details and requirements of soil testing in the laboratory that would enable the proper evaluation of the soil parameters used in the detailed engineering stage. The Owner/Owner's representative reserves the right to direct the Contractor to perform any particular test during the course of the investigation. The Contractor shall keep furnishing preliminary copies of all test results to the Owner/Owner's representative for their review.


### Soil Report

The soil report shall include but not limited to the following.

- A detailed write up on the procedures adopted in all phases of the soil investigation.
- A plan of bore hole and field test locations.
- Individual bore logs indicating various soil strata encountered their thicknesses and classifications, sampling locations, ground level, laboratory test results, SPT blow counts, ground water level and pertinent data.
- Cross section of soil profile in two perpendicular and diagonal directions and all load test curves & consolidation test curves.
- Detailed test results, laboratory observations both in tabular and graphical form and necessary extracts from technical literature used in calculation, evaluation & recommendations.
- Recommendation for type, depth, ultimate and safe bearing pressure and settlement of foundations for various structures.
- A summary of all design parameters.

The Contractor's recommendations shall include specific and definitive information on the following, supported by detailed calculations.

- a. Founding depths for various foundations as given below and corresponding safe soil bearing capacities evaluated from both strength and settlement considerations. Values obtained from field tests and laboratory tests shall be compared and suitable interpretation shall be furnished.
  - i) Heavy foundations for powerhouse building columns, boilers.
  - ii) Heavy machine foundations such Turbo generator foundation, FD fans etc.
  - iii) Foundations for smaller and larger circular storage tanks.

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- iv) Light foundations for non-plant buildings, sheds, compound wall, small pumps etc.
- b. Consolidation and settlement characteristics.
- c. Coefficient of sub grade reaction.
- d. Dynamic properties of soil.
- e. Type and capacity (vertical and lateral) of piles, if necessary, and data/ information on related aspects.
- f. Anticipated problems during foundation construction and recommended solutions.
- g. Roads, paving and grade slabs.
- h. Harmful chemical contents in soil and ground water, if any, and recommendations to protect underground structures from their harmful effects.
- i. Coefficient of earth pressure to be adopted for design of retaining structure.
- j. Specification for soil to be used for backfilling.
- k. Swelling characteristic of soil clearly indicating all swelling pressure etc.

### 5.5.2 Earthwork in Site Grading & Embankment

#### Scope

This specification covers the requirement in respect of materials, workmanship and quality for clearing, grubbing, grading, forming embankments and compacting of the areas in all kinds of soil.

#### Codes and Standards


Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

- IS:2720 Method of test for soils - grain size (Part 4) analysis
- IS:2720 Method of test for soils - Determination (Part 5) of limit & plastic limit
- IS:2720 Method of test for soils - Determination (Part VII) of water content - dry density relation using light compaction.
- IS:10379 Code of practice for field control of moisture and compaction of soils for embankment and sub grade.

#### Materials

Earth used for filling shall be selected earth as approved by the Owner/Owner's representative and free from organic and other objectionable matter. As far as possible excavated earth from excavation for foundations within the project area shall be used for filling. All clods of earth shall be broken or removed. Expansive soil shall not be used. The Contractor shall indicate in his offer the location of borrow areas and type of soil that he proposes to use.

Soil having plasticity index less than 20 and maximum proctor laboratory dry density more than 1.5 gm/cc shall only be used.

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Adequate dewatering facilities like dewatering pumps, pipes etc. shall also be provided by the Contractor for this work including for excavation in borrow areas at his own cost.

**Initial Levels**

The Contractor shall carry out the survey of the site before starting any work by taking accurate cross-section of the areas perpendicular to established grid / reference lines at 10 m interval or other intervals chosen by the Owner/Owner's representative based on the ground profile. For embankments initial levels shall be taken along the line of embankment and at right angles to the proposed alignment. These shall be checked by the Owner/Owner's representative and thereafter properly recorded.

**Clearing**

The area to be graded shall be cleared of plants, logs, stumps, bush vegetation, rubbish slush etc. If any roots of stumps of trees are met they shall also be removed. The material so removed shall be disposed of as directed by the Owner/Owner's representative, including burning if necessary. Trees to be cut shall be marked and the Owner/Owner's representative's approval taken before felling them. After the tree is cut and roots taken out the pot holes formed shall be filled with good earth in 250 mm layers and compacted. The tree shall be cut in suitable pieces as instructed by the Owner/Owner's representative, stacked and delivered to the Owner/Owner's representative. After the area is cleared of plants, logs, vegetation etc., the filling area shall be compacted with power roller of 8 - 10 tonne capacity to obtain 90% of maximum proctor laboratory dry density of top soil as per IS:2720 part VII, Initial level shall be taken again as described in the above clause. These initial levels shall be considered for calculation of compacted volume of fill subsequently.

**Grading**

The grading shall be carried out so as to obtain the levels indicated in the drawing after compaction. Generally such grading includes cutting and filling. The Contractor may employ any suitable means, mechanical, manual or a combination of both. The filled up area shall normally be filled with selected earth in layers of 250 mm (in loose condition uncompacted thickness) and compacted using rollers so as to obtain a density desired by the Owner/Owner's representative, normally minimum of 95 % of Proctor dry density for cohesive soils and 85% of Relative Density for non-cohesive soils.

When a layer of loose earth over an area has been removed during grading, the area shall be prepared by ploughing to loosen the earth before addition of soil to make up the lost earth. After the addition of soil over the ploughed area, it shall be compacted to the desired density.

**Embankments**


The finished formation width, side slopes and grade of the embankment shall be true to the line and level as shown on the drawings.

The embankment shall be made up in layers not exceeding 250 mm thickness (uncompacted thickness), over the whole width between the surface of the side slopes and shall be slightly concave in section so as to retain the water for water subsidence. All large clods shall be broken up.

When the embankments are on side-long ground the whole area of the embankment on slope shall be benched out or stepped so as to prevent the material from slipping.

In construction of embankment over the culverts or pipe drains care shall be taken to bring the embankment up, equally on both sides and over the top of the structure. Earth embankment shall be compacted as specified under Grading. In rock embankments, the rock filling shall be carefully packed to the depths as shown on the drawing.

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If embankments are made from borrow pits, the Contractor shall excavate the earth from borrow pits at the locations indicated on the drawings. They shall be regular in width and shape and shall be properly graded, drained and finished with neatly trimmed slopes.

#### Testing and Acceptance Criteria

The degree of compaction shall be as specified above or as decided by the Owner/Owner's representative as per site conditions. The actual method for measuring the compaction will be decided by the Owner/Owner's representative. The Contractor shall carry out at his own cost the required tests to prove that the soil has been compacted to the desired dry density. These tests shall be carried out at different stages of filling and also after entire fill height has been completed. Since the degree of compaction largely depends on moisture content of soil, a close watch shall be kept on it and corrections done to optimise the moisture content. Generally the moisture content shall be brought to within plus or minus 2% of optimum moisture content prior to rolling. The quality control operations shall include but not limited to the following items of work.

- i) Lines, levels and grades
  - a) Periodic surveys
  - b) Establishment of markers, boards etc.
- ii) Grading
  - a) Checking the quality of fill material
  - b) Checking moisture content of fill material
  - c) Checking degree of compaction

The Contractor has to offer inspection request on each layer and Owner/Owner's representative may take the inspection on degree of compaction if desires. If a layer fails to meet the required density, it shall be reworked or the material shall be replaced and method of compaction/equipment altered as directed by the Owner/Owner's representative to obtain the desired density.

#### 5.5.3 Concrete Piling


##### Scope

This specification covers the requirement in respect of materials, installation and testing of driven cast-in-situ, bored cast-in-situ, driven precast and bored precast concrete piles.

##### Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions (with all official amendments) as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

- IS:2131 Method of standard penetration for soils
- IS:2911 Code of practice for design and construction of pile foundation.

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**Materials**

The materials, cement, aggregates, steel used in the work shall be as specified hereunder:

Cement Portland slag cement conforming to IS-455 with minimum 50% slag or Portland pozzolana cement conforming to IS:1489 shall be used for construction, however if detailed final Soil Investigation Report recommends for more severe cement, the same shall be used without any extra cost to Owner/Owner's representative.

Aggregate Machine crushed blue granite conforming to IS:383.

Steel TMT/High Yield Strength Deformed steel bars of grade Fe-500 bars conforming to IS-1786. painted with fusion bonded epoxy coating as per IS:13620 shall be used for reinforcement.

Water used for mixing shall be potable water conforming to IS:456.

**Requirements for Precast Piles**

Precast piles shall be of octagonal shape, unless otherwise specified or approved by the Owner/Owner's representative.

The casting yard shall be so arranged that piles can be lifted directly from their beds and transported to the installation point with a minimum of handling.

Piles shall be cast in one operation. The form boxes shall be robust and clean using horizontal steel shutters of suitable length. The concrete shall be vibrated with the aid of shutter/immersion vibrators. Care shall be exercised that no cement slurry is lost. All faces of the piles shall be worked to be as smooth and dense as possible, including the exposed face at the top.

The cross-sectional dimensions of the pile as cast shall not be less than the specified dimensions and shall not exceed them by more than 6 mm. Further, any face of the pile shall not deviate by more than 6 mm from a straight edge 3 m long, laid on the face. The centroid of any cross-section of the pile shall not deviate by more than 12 mm from the straight line connecting the centroids of the end faces (head and tip) of the pile, or 1/500 of pile length, whichever is the least.


Side shutters shall not be struck till after 24 hours from the time of casting or later if so instructed by the Owner/Owner's representative.

Piles shall not be moved from the beds on which they were cast until the concrete has sufficiently hardened. This period shall be a minimum of 10 days for ordinary Portland cement/Sulphate resistant Cement concrete and 7 days for rapid hardening Portland cement concrete from the time of casting. Care shall be exercised by the Contractor during such movement that the pile does not crack or chip.

Piles shall be kept continuously wet for ten days from the time of casting, but longer curing shall be done, as directed by Owner/Owner's representative, when hard driving is expected.

When piles are stacked between the period of wet curing and driving/installing, they shall be protected from rapid drying by sheltering them from the wind and direct sunlight by covering the stacks.

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All care shall be taken at all stages of transporting, lifting and handling of the piles to ensure that they are not damaged or cracked. During transport, the piles shall be supported at the appropriate lifting hooks provided for the purpose. If the piles are put down temporarily after being lifted, they shall be placed on trestles or blocks located at the lifting points.

Piles shall be provided with a coaxial cast iron or steel shoe for protecting the tip of the pile during driving, as indicated on drawing. The area of the tip of the shoe shall be such that the stress in the concrete in this part of the pile is within the safe limits.

For precast piles to be installed in pre-bored holes, a grouting pipe of appropriate diameter shall be embedded along the centre line of the pile for the entire length.

**Requirements for Driven Piles**

Standard helmet of cast-steel or structural steel shall be fitted on the pile head, unless a follower is required, to ensure axial alignment of the hammer and pile at instant of impact. Short hardwood dolly in one piece not thicker than the width of the pile with grains parallel to the pile axis shall be used with the helmet and shall be closely fitted inside the recess on top of the helmet. A steel band is to be pressed over the top of the dolly to prevent it from splitting. A steel plate of 25 mm minimum thickness shall be used on top of the dolly to distribute the hammer blows. The use of wood chips, small wood blocks or such other materials is prohibited. The Contractor shall note on the driving log when fresh cap block material is placed under the hammer and shall discount the measured resistance to driving immediately thereafter.

It is desirable that double acting diesel/ compressed air/steam operated hammers are used for driving the pile. Single acting hammers may be used only if permitted by the Owner/Owner's representative. The Bidder shall submit with his Bid, the details of driving equipment to be specifically deployed on this job. It shall be the responsibility of the Contractor to use the right equipment for driving. The Contractor shall satisfy the Owner/Owner's representative regarding suitability, efficiency and energy of driving equipment. The hammer blows shall always be in line with the pile axis. Drop of each and every blow shall be controlled and monitored.


The heaviest practical hammer with drop or stroke limited to the minimum shall be employed so as not to damage the pile. In any case, the weight of the hammer shall exceed 10 times the weight of 1.0 M length of the pile. Long continued driving after the pile has almost ceased to penetrate, shall be avoided. Care shall be taken not to damage the piles by overdriving. Any sudden change in the rate of penetration, which cannot be ascribed to the nature of the ground, shall be noted and its cause ascertained, if possible, before driving is continued/pile is accepted.

The Contractor under the supervision of the Owner/Owner's representative shall take temporary compression or rebound set curves on the piles during driving, as described in IS-2911. These shall be taken at a few pile penetration depths and at the final set, on the first few piles of each size and/or length. The values of (C1 + C2 + C3) thus obtained shall be used to recheck and modify if necessary the required "Set" for the safe load bearing capacity specified for the pile.

The final set of each pile shall be recorded as the penetration in millimetres per 10 blows.

Set criterion shall be mutually agreed upon on the basis of set recorded for piles for initial pile load tests, the Contractor's pile driving equipment, etc. In case of any conflict or disagreement, decision of the Owner/Owner's representative shall be binding.

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## Installation of Piles

### General

#### - Location of Piles

A plan in triplicate showing clearly the designation of piles to be installed by an identifying system shall be submitted to the Owner/Owner's representative before the installation of piling is started.

#### - Trial bore holes

To ascertain the founding strata, especially for precast driven piles, trial bore holes shall be carried out.

#### - Record of Piles

The record shall be kept by the Contractor in an approved form of the total penetration of every pile and the behaviour of each pile during driving / boring. Type of soil encountered, depth of boring/driving, depth of water table, cut-off level working level, time taken for concreting, consumption of cement, density of bentonite slurry and all other important observation shall be indicated in the standard record format. Any deviation from the designated location, alignment or load carrying capacity or any upheaval noticed only any pile during installation shall be immediately reported to the Owner/Owner's representative and adequate corrective measures taken as decided by the Owner/Owner's representative. On the completion of pile installation, pile driving / boring records together with the records of such changes or other sub-surface information that were obtained during the installation of piles shall also be submitted by the Contractor with the Owner/Owner's representative in triplicate.

### Sequence of Installation

The Owner/Owner's representative shall decide the sequence of the group of piles that the Contractor should undertake for installation and Contractor shall proceed from those in the centre of the group towards those on the periphery or from one side to other.

### Installation


#### - General

Piles shall be installed with due consideration for safety of adjacent structures, working equipment etc by a method which leaves their strength unimpaired & which develops and retains the required load bearing capacity.

#### - Driven cast-in-situ piles

Steel casings, shall be straight and shall have sufficient wall thickness and strength to withstand without damage, distortion etc., the handling stresses and driving stresses set up in obtaining the specified depth and set and to resist harmful distortion or buckling due to soil pressures developed during installation of pile or adjacent piles. Joints shall be welded or lock seamed. Casings and their joints shall be sufficiently tight to exclude water.

Casings shall be of such diameter as to give the specified nominal diameter of the pile. Casing lengths shall be the maximum consistent with standard practice, transport, handling and driving facilities.

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Detachable shoes shall be of cast iron or mild steel and of requisite strength of the standard sizes used with the respective steel casings and the shoe shall be coaxial with the steel casing.

In case of piles close to the existing plant & structures, the Owner/Owner's representative if necessary, may specify the fall of smaller than the standard and working hours for the rig & no extra claim shall be entertained due to these restrictions. The equipment and methods for installing piles shall be such that the loss of energy is limited to a suitable minimum.

Casings distorted from true and uniform shape, whether caused by driving or earth and water pressure, resulting in a reduction of the cross-sectional area of the pile in excess of 10% shall not be used on the work.

If there is a major variation between the depths at which adjacent foundation piles in a group meet refusal, a boring shall be made nearby to ascertain the cause of this difference. If the boring shows that the soil contains pockets of highly compressible material below the level of shorter pile, the pile shall be taken below the bottom of such layer.

Provisions of IS: 2911 (Part 1/Sec.1) shall be adopted for requirements not covered above.

- **Bored cast-in-situ piles**

Bored cast-in-situ piles shall be installed by suitable choice of techniques covering the manner of soil-stabilisation i.e. the use of casing and / or use of drilling mud, manner of concreting i.e. direct pouring and placing or by use of tremie and choice of boring tools in order to permit a satisfactory installation of pile. Preferably Direct Mud Circulation method shall be adopted for installation. The bentonite and bentonite slurry shall meet the requirement specified in IS. A minimum length of 1 meter of temporary casing shall be inserted in each bored pile. In case of collapsible soil strata, the full depth of boring shall be provided with temporary casing. If piles are founded on rocky strata, the casing shall be keyed for a minimum depth of 150 mm. After the borehole has been drilled to its final depth, fresh bentonite slurry shall be pumped through the chisel resting at the base of hole, to remove completely all cuttings and other loose materials from the base of pile. During this flushing the speed of pump shall be increased to maintain additional high pressure for 10 - 15 minutes. After the hole has been thoroughly flushed, the chisel and API rods shall be removed for the concrete. When installing piles in a group, sufficient time shall be allowed for freshly poured concrete in the adjacent pile to set.


Provisions of IS: 2911 (Part 1/Sec.2) shall be adopted for requirements not covered above.

- **Driven Precast Piles**

A minimum period of 28 days shall be allowed for curing from the time of casting the pile, before selecting the pile for driving. This period may be relaxed by the Owner/Owner's representative if he is satisfied that the pile has achieved adequate strength to take up driving stresses without suffering distress. In such case the Contractor shall obtain expressed permission of the Owner/Owner's representative in writing.

Driving shall be performed with fixed leads or leaders capable of holding the pile firmly in position, with the hammer and the pile in axial alignment. Care shall be taken during driving to prevent and correct any tendency of the pile to twist or rotate. Pile drivers shall have firmly supported leads extending down to the lowest point the hammer must reach.

Where cut off levels are below grade level, the Contractor shall be required to use followers to drive the pile further below ground level when the head of the pile is near ground level.

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In general, driving sequence of piles and clusters of piles shall, unless otherwise specified by the Owner/Owner's representative, proceed from the centre of the pile groups and progress outward from the centre, towards any two opposing sides of the perimeter.

Piles shall be driven in a continuous manner, without interruption, until the pile has been driven to final elevation of specified resistance, or a combination of both as shown on the drawings or as directed by the Owner/Owner's representative. Where, in exceptional cases driving is interrupted before final penetration is reached, the set per blow immediately upon retrieving shall be disregarded and such pile shall be driven to the final elevation to which the adjacent piles, which were not interrupted, have been driven.

Piles shall be driven in such manner that previously driven piles are not damaged/affected including partly set concrete of lengthened piles.

Piles shall not be abandoned partially driven at the end of the shift.

When a pile head is damaged during driving, the head shall be cut-off square at sound-concrete level, and all loose particles shall be removed by wire brushing, followed by washing with water. If pile is subjected to further driving, the head shall be replaced by concrete of an approved grade. Such piles shall not be driven until appended concrete has reached the specified strength.

If the driving of the pile has been accepted but sound concrete of the pile is below the cut off level, the pile shall be made good to the cut-off level with concrete of a grade not inferior to that of the concrete of the pile. While lengthening the pile, joints in the reinforcement shall be such that the full strength of the bar is effective across the joint. Welded joints shall be made in accordance with IS: 816 and/or IS: 1323 and the main longitudinal reinforcing bars in the head of the pile shall be exposed for at least 300 mm below the weld. For lap or splice joints sufficient link bars shall be provided to resist eccentric forces.

Provisions of IS:2911 (Part 1/Sec.3) shall be adopted for requirements not covered above.

**- Bored Precast Piles (Precast Pile Installed in Prebored Hole)**

Boring shall be similar to that for bored cast-in-situ piles.

Where indicated by site conditions, precast piles in prebored holes shall be socketed into competent stratum as indicated on the drawing or as directed by the Owner/Owner's representative.


In order to determine the competency of the stratum including rock for socketing as well as supporting the pile, standard penetration tests (SPT) shall be conducted during the progress of boring/chiselling into the stratum including rock.

The precast pile shall be brought near the borehole and lifted in vertical position. The pile shall be suspended over the borehole. The flush water shall be switched on through the central grout passage in the pile as the pile tip approaches the founding strata. On reaching the founding strata, water flush shall be continued for 10-15 minutes. Flushing shall be done under adequate pressure in order to ensure the cleaning of borehole bottom of any soft/cohesive material.

After cleaning the bottom of borehole, cement/sand grout (1 cement: 2 sand) with W/C ratio of 0.55 shall be pumped through the grouting pipe in the pile so as to grout the base and fill up the annular space around the pile. The grouting pressure shall be adequate to grout the full length of the pile. The minimum thickness of the grout mantle shall be 40 mm.

Temporary liners/casings if provided shall be extracted progressively as the grout level inside the borehole rises.

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Provisions of IS: 2911 (Part 1/Sec.4) shall be adopted for requirements not covered above.

**Jetting of Piles**

Jetting of piles by means of water shall not be permitted.

**Reinforcement**

All reinforcement for use in pile shaft shall be assembled and joints in longitudinal bars, if unavoidable, shall be made by lapping and the lap shall be tack-welded to prevent distortion of the reinforcing cage. The projecting length of the longitudinal bars beyond the pile cut-off level shall be equal to 50 times bar diameter. Minimum cover shall be 50 mm; however in aggressive soil cover shall be increased to 60 mm.

The helical reinforcement shall fit tight against the longitudinal bars and be fixed to them by soft annealed 16 gauge block iron wire, the free ends of which shall be turned into the interior of the pile.

In addition, lateral circular templates with 8 mm dia bar shall be provided at spacing specified by the Owner/Owner's representative and longitudinal bars shall be welded to templates. Care shall be taken to preserve the correct cover and alignment of reinforcement free from any twist, throughout the operation of placing the reinforcing cage into the borehole and concreting of pile.

**Concreting work in cast-in-situ piles**

The specifications laid down for concrete work shall also apply to the concrete work for piles, except as modified in this specification. The Contractor shall submit mix design as per IS method or ACI Code 211.1 and carry out adequate number of tests to ensure the minimum strength. The minimum cement content and the maximum water cement ratio considered in mix design shall be 400 kg/m<sup>3</sup> and 0.45 respectively unless otherwise specified. The slump (130 - 180 mm flowing consistency for bored piles, 80-100 mm flowing consistency for driven piles) shall be selected by the Contractor based on the suitability of the chosen method of concreting for pile installation. If, during execution, workability is to be increased, higher cement content or admixtures shall be used with Owner/Owner's representative's approval.

The concrete shall be freshly mixed and of sufficient quantity in the casing (where used) to ensure that during the withdrawal of the casing, a sufficient head of concrete is maintained to prevent inflow of subsoil and ground water and to prevent formation of necking or wasting.

Exposed portions of piles be cured for ten (10) days.


When installing piles in a group, sufficient time shall be allowed for the freshly poured concrete in a pile to set before installing adjacent piles.

All care shall be taken to prevent formation of voids in the pile by pockets of air trapped within. Particular attention shall be paid to this during withdrawal of casing. The volume of concrete placed shall be checked against calculated volume of pile at the time of withdrawal of casing.

**Minimum Casting Levels**

Piles shall be cast at least 500 mm above the finished cut-off level so as to permit the removal of all laitance and weak concrete.

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## Testing of Piles

### General

The Contractor shall cast/drive test piles for each kind of loading and carry out the load bearing tests before actually commencing the work unless otherwise specified, the number of test piles shall be based on the criteria specified in IS:2911(Part 4). The Contractor may be allowed to use quick setting cement or add the necessary admixtures to enable him to conduct the test within seven (7) days after installation for cast-in-situ piles or within 7 days of casting for precast piles.

The load tests shall be carried out by the Contractor as described herein. the load test on working pile however shall not normally be undertaken by the Contractor within 28 days after the installation of the pile in position for cast-in-situ piles or 28 days after casting precast piles. The vertical load test shall be carried out on single pile. The lateral load test shall be carried out between two piles. Before any load test is made the proposed arrangement for carrying out the load test including the preparation of the structure to receive the loads and the type of loading to be adopted shall be furnished by the Contractor and approved by the Owner/Owner's representative. The load tests shall be made under the supervision of the Owner/Owner's representative. The complete record of such loads shall be filed with the Owner/Owner's representative in triplicate. The responsibility for carrying out such load tests satisfactorily and safely and on proper lines rests with the Contractor.

The test shall be carried out at cut-off level wherever practicable, otherwise suitable allowance shall be made in the interpretation of the test results.

### Method of Testing

The testing shall be conducted according to IS:2911, Part IV as described herein. If there is any discrepancy observed between the IS guidelines and the specification given here, the following guidelines shall be governing.

- Vertical load test (compression)


The test load to be applied on the loading platform supported on pile shall be

- a) 2.5 times the proposed safe designed load in case of test pile.
- b) 1.5 times the proposed safe designed load or upto a maximum settlement of 25 mm whichever occurs earlier in case of working pile.

The load increments shall be

- a) 1/5, 2/5, 3/5, 4/5, 1, 1.25, 1.5, 1.75, 2, 2.25 and 2.5 times the safe designed load in case of test pile and
- b) 1/5, 2/5, 3/5, 4/5, 1, 1.25 & 1.5 times the safe designed load in case of working pile.

Readings of settlements shall be recorded with minimum 2 dial gauges of 0.01 mm sensitivity each positioned at equal distance around the pile and normally held by datum bars resting on immovable supports at a distance of 3D (subject to minimum of 1.5 m) from the edge of the pile where 'D' is the stem diameter of circular piles or diameter of circumscribing circle in the case of square or non-circular piles.

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Taking of measurement or displacement of the pile top for each load increment is continued until the settlement is either 0.1 mm in first 30 minutes or 0.2 mm in first one hour or till 2 hours whichever occurs first.

The final test load shall be maintained for 48 hours. The safe load on single pile for the test pile shall be at least of the following:

Two thirds of the final load at which the total displacement attains a value of 12 mm.

50 percent of the final load at which the total displacement equal 10 % of the pile diameter in case of uniform diameter piles and 7.5 % of bulb diameter in case of under-reamed piles.

**- Lateral Load Test on Pile**

The safe lateral design load shall be the least of the following:

- i) 5% of the safe axial load.
- ii) Load corresponding to a maximum calculated deflection of 5 mm.

The test load shall be

- a) 2.5 times the proposed safe lateral design load or 12 mm whichever occurs later in case of test piles.
- b) 1.5 times the proposed safe lateral design load or 7.5 mm whichever occurs earlier in case of working pile.

The load increments shall be similar to the one given for the vertical load. The safe lateral load on a single pile shall be taken as the least of the following :

- a) Fifty percent of the final load at which the total displacement increases to 12 mm.
- b) Final load at which the total displacement corresponds to 5 mm.

**- Cyclic Load Test on Pile**

Alternate loading and unloading shall be carried out at each stage as given in relevant clause and each loading shall be maintained as given in relevant clause and each unloading stage shall be maintained for atleast 15 minutes and subsequent elastic rebound in the pile shall be measured accurately as specified in relevant clause. This test shall be continued upto 1.5 times the proposed safe design load. The skin friction and end bearing load of the pile shall be separated out either by graphical method or analytical method as described in IS.


**- Pull out Test**

Pullout test requirements shall be as per IS:2911 (Part 4).

**Acceptance Criteria**

The following are the general acceptance criteria.

The clauses pertaining to acceptance of concrete work as described for Plain and Reinforced Concrete work shall also be applicable to the work of piles.

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**Positional Tolerance**

The permissible positional deviation of pile should not be more than 75 mm or D/4 whichever is less where 'D' is the diameter of pile (75 mm or D/10 whichever is more in case of piles having diameter more than 600 mm) at the working level. In the case of single pile under a column the positional deviation should not be more than 50 mm or D/4 whichever is less (100 mm in case of piles having diameter more than 600 mm). This will be measured after the driving of the pile and during the inspection of the tube prior to placing of reinforcement and concrete. Should the deviation be greater than that specified above, the Contractor shall remove the casing at his own cost & redrive the pile, if ordered so by the Owner/Owner's representative.

In the alternative, the Owner/Owner's representative may at his discretion order the driving of additional piles at the Contractor's cost which he considers necessary after checking up the design load on the pile group.

**Pile size & capacity**

The Contractor shall guarantee 90% of full cross sectional area of the pile and also guarantee against occurrence of necking of wasting, bulging, spalling of shaft concrete, exposure of reinforcement, porous concrete and similar defects which will impair the strength and durability of pile. The Owner/Owner's representative may direct the Contractor to completely exhume some or all test piles before or after load testing to examine the quality of the pile shaft. This shall be done either by excavating around the pile or by pulling out or by a combination of both methods. If the quality of the pile shaft does not satisfy the requirements of this specification and/or if the pile fails to attain workmanship or negligence on the part of the Contractor, all costs of mobilisation, installation and testing of test piles exhuming of test piles and any other work in connection with the test piles shall be to the cost of Contractor.

**Structural Soundness**

The concrete should have the minimum strength specified based on the cube test. The acceptance criteria mentioned in the specification for concrete works under Clause 4.5.0 shall be referred in this aspect. However the Owner/Owner's representative reserves the right of rejecting any pile which in his opinion is not structurally sound or is not in proper position and alignment. The Contractor shall be bound to pull the same out and re-install a new pile in its place or leave the defective pile and install at the Contractor's cost one or more additional piles to substitute the defective pile, as per directions of the Owner/Owner's representative.

**5.5.4 Earthwork in Excavation & Backfilling**

**Scope**


This specification covers the requirement of site clearing, excavation & backfilling in all types of soil for foundations, basements, trenches, drains, culverts etc.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

IS:1498                      Classification and identification of soils for general engineering purposes.

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- IS:3764 Safety code for excavation works
- IS:4081 Safety code for blasting and related drilling operations
- IS:9759 Guidelines for dewatering during construction

**Setting Out**

The work shall be set out to exact dimensions as shown on the drawings and shall be checked and approved by the Owner/Owner’s representative before commencement of excavation.

In firm soil, the sides of excavation in foundations shall be kept vertical up to a depth of 1.5 m from the bottom and for greater depths the sides shall be widened by forming steps of 300 mm on either sides after every 1.5m from the bottom. Where soil is soft, loose or slushy, the width of steps shall be suitably increased or the side sloped or shored up, as directed by the Owner/Owner’s representative. Working space shall be approved by the Owner/Owner’s representative.

In case of excavation for pipes, the authorized width of excavation shall be 600 mm plus outer diameter of pipe or the width of bedding as shown in the drawing whichever is higher, upto a depth of 1.5 m. For higher depths, the width shall be widened by forming steps of 300 mm on either side after every 1.5 m from the bottom.

**Initial Levels**

Initial levels either in a definite grid pattern or as directed by the Owner/Owner’s representative shall be taken by the Contractor jointly with the Owner/Owner’s representative over the original ground prior to starting actual excavation work and after setting out.

**Clearing and Grubbing Etc.**


The area to be excavated shall be cleared out of trees, logs, stumps, bush, vegetation, rubbish, slush etc. and leveled up. Trees up to 300 mm girth shall be uprooted. Trees above 300 mm girth shall be cut up to 600 mm below ground level. Useful materials, saleable timber shall be the property of the Owner/Owner’s representative and hence shall be handed over. All the spoils and unserviceable materials and rubbish shall be burnt or removed from site to approved disposal areas as may be specified.

**Excavation and Cutting**

The Contractor shall excavate to remove materials of any nature or description which may be encountered and excavate to depths, widths and inclinations as shown on the drawings and/ or as directed. The bed of the excavation shall be made level and firm by watering and ramming. The Contractor shall not remove any tree without permission.

While carrying out excavation for drain work, the sides and bottom shall be cut to the exact shape, slope and gradient as shown on the drawings. The surface shall be properly dressed. Excavated material shall not be placed within 1.5 m from the edge of any excavation or half of trench depth whichever is more.

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**Excavation in Rock**

Blasting where permitted shall be carried out as specified in IS:4081. Where blasting is prohibited, rock excavation shall be by chiseling, wedging or any other approved method. Depending on the exact location of rock excavation, decision to excavate by blasting or not will be taken by the Owner/Owner’s representative.

**Variation in Excavation**

**Bad Soil**

Should the bottom of any excavation at design depth appear to be soft, unsound or unstable, the Contractor shall report the matter to the Owner/Owner’s representative and if the Owner/Owner’s representative so directs, shall excavate the same to indicated depths. The extra depth shall be filled up with concrete or such other materials as the Owner/Owner’s representative shall direct. No extra compensation will be entertained in this account.

**Excavation Too Deep**

If the Contractor excavates to levels deeper than those shown on drawings for any reason other than those stated above, he shall fill it up at his own expense to the proper level with lean concrete 1:5:10 or sand filling as directed. No payment will be made for excavation taken down to depths more than those shown on the drawings or for the filling carried out as directed.

**Slips and Falls**

Every precaution shall be taken against slips and falls of earth, clay, sand or other materials in the excavations, but in the event of any such occurring; the Contractor shall at his own expense make good the space affected by slips or falls even if the affected area is outside the dimension of the work ordered.

The Owner/Owner’s representative will determine in each case whether such affected area is to be filled up in whole or in part with concrete, brickwork or masonry of the quality used in the adjoining work or where only a part is to be so filled, the materials to be used for this remaining part.

If in the opinion of the Owner/Owner’s representative there is a possibility of the newly constructed work having been damaged or disturbed by such collapse, the work shall be laid bare at the expense of the Contractor for inspection. Any damage caused shall be made good by the Contractor, at his own expense.


**Soil/Sub-soil Water Condition**

Boring and sub-surface data regarding the nature of soil, sub-soil water furnished to the Contractor shall be taken as guidance only and variation there from shall not affect the terms of Contract. The Contractor must satisfy himself regarding the character and volume of all work under this item and expected surface, and/or sub-soil water to be encountered.

**Keeping Works Site Free From Water**

The Contractor shall provide and operate pumps and all other equipment necessary to drain the sub-soil water, rain water etc. to the nearest sewer or drain through properly laid pipes or channels and keep excavation pits, trenches etc free from water at all times during excavation, backfilling and the continuance of the contract. Adequate care shall be taken to prevent movement of water through freshly laid concrete or masonry work. Sumps made for dewatering shall be kept clear of

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the foundation. Method of dewatering shall be approved by the Owner/Owner's representative but in no case the pumping arrangement shall be such that there is any movement of sub-soil or blowing-in due to differential head of water during pumping. If water table is high, well point dewatering has to be adopted for excavation beyond 1 metre below the water table. The dewatering shall be continued for a sufficient period so as not to affect the strength and other properties of the concrete. Guideline given in IS: 9759 shall also be followed.

**Protection of Work**

The Contractor shall support and maintain adjoining and abutting property and structures to render work safe to persons and property.

The Contractor shall provide necessary decking, guard, fencing, planking with red flags and red lights at night to maintain safe pedestrian and vehicular traffic near all open excavations.

**Shoring and Strutting**

Shoring and strutting shall be used as directed when excavation is to be carried out in soft or slushy soil which is likely to collapse during the excavation of the work. The shoring shall be either open or close boarded type depending on the nature of the soil and depth of excavation and the type adopted shall be as directed by the Owner/Owner's representative. While excavating in very unstable ground requiring support throughout the period of excavation, runners shall be used and shall be driven always in advance of the excavation. The size and spacing of different members to be used in shoring shall be as directed by the Owner/Owner's representative, depending on the site conditions. If however slips do occur, the same shall be removed by him and backfilled later by him at his own expense. The withdrawal of shoring & shoring material shall be done very carefully to prevent the collapse of pit or trench. No claim shall be entertained for any material which cannot be removed and is lost or buried.

**Disposal**

The excavated earth shall be disposed off in the following manner or as directed by the Owner/Owner's representative

- i) By keeping separately the materials suitable for backfilling/area filling and material not suitable at areas to be designated by the Owner/Owner's representative.
- ii) The excess material remaining after back-filling/area filling shall be spread evenly so as to allow natural flow of water in the area.


**Backfilling and Filling in Plinth**

Earth used for filling shall be free from organic and other objectionable matter. As far as possible, materials obtained from excavation in foundation shall be used. The earth shall be basically CNS soil (Cohesive Non-Swelling Soil). All clods of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not bigger than 150 mm in size and mixed with fine materials consisting of decomposed rock, moorum or earth and the mixture shall be used for filling. Expansive soils shall not be used for filling. Maximum thickness of filling (uncompacted) shall be 200mm and compacted to 95% of proctor density.

**Filling Around Foundation with Earth**

Filling shall be carried out in layers not exceeding 200 mm (un compacted thickness) in depth. Each layer shall be watered, rammed and properly compacted to 95% of proctor density or 85% of relative density depending on the soil type. For Turbine Foundation it shall not be less than 98%.

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**Sand filling in plinth**

Sand used for filling shall be free from dust, organic and other objectionable matter and shall not contain more than 10 percent of clay.

When filling has reached the appropriate level, the area shall be flooded with water for a minimum period of 24 hours to allow the fill to settle. The filling shall be allowed to dry and then compacted and dressed to the required level.

**Filling in trenches for pipes**

Filling in trenches for pipes shall be commenced as soon as the joints of pipes have been tested and passed. Filling of trenches shall be carried out simultaneously on both sides of pipes to avoid unequal pressure on the pipe. The earth shall be spread on the sides and top of the pipes in layers not exceeding 200 mm (un compacted thickness), watered, rammed and consolidated, taking care that no damage is caused to the pipe below. Maximum particle size for fill material around pipes shall be less than 20 mm.

**Testing and Acceptance Criteria**

**Excavation**

On completion of excavation, the dimensions of the pits will be checked as per drawings after the pits are completely dewatered, the work will be accepted after all under-cuts are set right, all over excavations are filled with lean concrete or compacted earth as directed and all necessary shoring & strutting done, all temporary approaches to the bottom of trenches provided, all to the satisfaction of the Owner/Owner’s representative.

**Backfilling / Plinth Filling**

All filling shall be done to the compaction specified. The backfilling work will be accepted only after the Owner/Owner’s representative is satisfied with the degree of compaction.

Level of each layer of backfilling shall be marked on the sides in order to exercise the control on the thickness of layer being laid.

**5.5.5 Plain and Reinforced Concrete Work**


**Scope**

This specification covers the requirement in respect of materials, workmanship and quality for Plain Cement Concrete (PCC) and Reinforced Cement Concrete (RCC) for all types of structures in foundation and superstructure.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

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**Cement**


- IS:269 Ordinary and low heat Portland cement
- IS:455 Specification for Portland slag cement
- IS:1489 Specification for Portland pozzolana cement
- IS:4032 Method of chemical analysis of hydraulic cement
- IS:6452 High alumina cement for structural use
- IS:8041 Rapid hardening portland cement
- IS:8112 Specification for 43 grade ordinary Portland cement
- IS:12330 Sulphate resisting portland cement

**Aggregate**

- IS:383 Coarse and fine aggregates from natural sources for concrete
- IS:2386 Methods of test for aggregates for concrete
- IS:2430 Methods of sampling of aggregates for concrete

**Concrete Plain and Reinforced**

- IS:456 Code of practice for plain and reinforced concrete
- IS:460 Test sieves
- IS:516 Methods of test for strength of concrete
- IS:1199 Methods of sampling and analysis of concrete
- IS:1607 Methods for test sieving
- IS:1834 Hot applied sealing compounds for joints in concrete
- IS:2645 Integral cement water proofing compounds
- IS:2750 Steel scaffolding
- IS:2974 Code of practice for design and construction of machine foundations
- IS:3370 Code of practice for concrete structures for the storage of liquids
- IS:9013 Method of making, curing and determining compressive strength of accelerated-cured concrete test specimens
- IS:9103 Admixtures for concrete
- IS:9893 Precast concrete lintels and sills

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- IS:10262 Recommended guidelines for concrete mix design
- IS:10297 Code of practice for design and construction of floors/roofs using pre-cast reinforced/pre-stressed concrete ribbed or cored slab units
- IS:10566 Methods of tests for preformed fillers for expansion joints in concrete paving and structural construction
- IS:10790 Methods of sampling of steel for prestressed and reinforced concrete


**Steel**

- IS:432 Mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement
- IS:1566 Hard-drawn steel wire fabric for concrete reinforcement
- IS:1568 Wire cloth for general purposes
- IS:1786 High strength deformed steel bars and wires for concrete reinforcement
- IS:2502 Code of practice for bending and fixing of bars for concrete reinforcement
- IS:2751 Code of practice for welding of mild steel plain and deformed bars used for reinforced concrete construction

**Materials**

All materials that shall be used for works covered under this specification shall conform to following standards / specification.

- Aggregate Machine crushed blue granite conforming to IS:383
- Cement
  - IS:269 - Ordinary Portland Cement
  - IS:455 - Specification for Portland slag cement
  - IS:8041 - Rapid Hardening Portland Cement
  - IS:8112 - High strength Ordinary Portland Cement
  - IS:12330- Sulphate Resisting Portland Cement
- Reinforcement IS:432/IS:1786/IS:1566
- Embedded plates IS:2062
- Binding wire PVC binding wires
- Joint filler Approved non extruding, resilient fillers
- Sand River or pit sand conforming to IS:2116
- Water stops PVC/Rubber/Metallic - GI, Aluminium, copper

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- Admixtures IS:9103
- Water Clean, potable as specified in IS:456.

Source of coarse & fine aggregate shall be approved by the Owner/Owner's representative.

Test certificates for each consignment of cement procured have to be submitted by the Contractor to ensure conformity with relevant standards. The Owner/Owner's representative may reject such cements supplied in the event of unsatisfactory tests or in the event of deterioration due to age or bad storage etc. Decision of the Owner/Owner's representative shall be final in this regard.

Admixtures shall be used only after getting permission from the Owner/Owner's representative and as per the instruction of the manufacturer.

### Grades and Proportioning


Any grades of concrete designated in latest revision of IS: 456 as shown on the drawings or as specified shall be used. Design mix concrete shall be adopted for all RCC works. Contractor, at his own cost shall get this Design Mix done by any premiere institute like approved by the Owner/Owner's representative. If the submitted results are not satisfactory to the Owner/Owner's representative, the Owner/Owner's representative has every right to reject the design mix. In case the Contractor fails to submit or comply with the design mix, he requires to follow Nominal Mix as per IS: 456 after obtaining the permission from Owner/Owner's representative. The mix shall be designed as per "Handbook on concrete mixes", SP:23. While designing the mix, the strength, durability, minimum cement content, maximum water cement ratio allowed and workability necessary for the job by most economical use of the various ingredients shall be considered by the Contractor. Contractor must use the same ingredients in the Design Mix which he uses in the works. The mix design shall be verified by carrying out preliminary test.

The water cement ratio, coarse aggregates and grading for each mix shall be predetermined from the results of cube tests of trial mixes. The mix proportions determined thus shall be followed at site and shall in no way relieve the Contractor of his responsibility as regards the prescribed strength mix. The mix proportions, however, shall be revised if the results of the cube tests during the construction show consistently lower than the prescribed one. No extra claim will be entertained due to such changes in mix designs, as the Contractor will be responsible to produce the concrete of required grade. The maximum size of aggregates used shall be as indicated in IS: 456 or specified elsewhere.

Nominal mix concrete in accordance with IS: 456 for grade M20 or lower may the used if shown on drawings or approved by the Owner/Owner's representative. In all cases the proportioning of ingredients and works control shall be in accordance with IS: 456 and shall be adopted for use after the Owner/Owner's representative is satisfied regarding its adequacy and after obtaining his approval in writing.

### Mixing

Mixing should be carried out in mechanical mixers. No hand mixed concrete is permitted for RCC works. Hand mixing if permitted for PCC works shall be carried out on a clean, hard and water tight platform. Water cement ratio shall be rigidly controlled during mixing. Mixers shall be fitted with automatic devices to discharge measured quantity of water to the mixing pan. The water shall not be admitted to the drum until the cement and aggregate constituting the batch are thoroughly mixed. Mixing shall continue until the concrete is uniform in colour and not less than 2 minutes and forty (40) revolutions after all the material and water are in the drum. Regular checks on mixer efficiency shall be carried out as directed by the Owner/Owner's representative. Only those mixers whose efficiencies are within the tolerances specified in IS: 1791 will be allowed to be employed. Batching

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plant where used shall conform to IS: 4925. Concrete shall be prepared only by weigh batching the ingredients. Volume batching will not be permitted.

The entire content of the drum shall be discharged before the ingredients for next batch are fed into the drum. No partly set or remixed or excessively wet concrete shall be used. Such concrete shall be immediately removed from site. Each time the work stops the mixer shall be thoroughly cleaned and when the next mixing commences, the first batch shall have 10% additional cement at no extra cost to the Owner/Owner's representative to allow for loss in the drum.

### Placing


Concrete shall be transported from the mixing plant to the forms, as rapidly as possible, by means which will prevent segregation, consolidation or drying out in hot weather. Concrete shall be placed within thirty (30) minutes after commencement of mixing. At the time of placing concrete in very hot weather, care shall be taken to see that the temperature of wet concrete does not exceed 38°C.

Before placing concrete, formwork, embedment's and reinforcement shall be checked for completeness, location and dimension. It should also be square and plumb. All chips and saw dust or other foul matter shall be removed from within the forms with the help of an air compressor. The base surface shall be well moistened and puddles wiped up. Earth foundation on which direct placement of concrete is allowed will be rammed and consolidated as directed by the Owner/Owner's representative such that it does not crumble and get mixed up with the water during or after placement, before it has sufficiently set and hardened. Concrete may be placed against moist surface but never on pools of water. In case the foundation cannot be dewatered completely, special procedure and pre-caution, as directed by the Owner/Owner's representative will have to be adopted. A layer of mortar of thickness between 12 mm to 25 mm as directed, of the same or less W/C ratio and the same proportion as that of concrete being placed and /or cement slurry will be spread thoroughly on the foundation or construction joint just prior to placement of concrete. Placing equipment and accessories shall be kept clean and free of partially set grout and concrete, and maintained in proper working order. Walking on reinforcement layers is not permissible. Walkways of wooden planks or similar can be placed with removable supports and should be independent of reinforcement.

In general, placing shall be direct, by transporting buckets. Where it is necessary to deposit the concrete at level differences of more than 1.5 m, short chutes shall be used. Short chutes and hoppers shall be so designed and installed that segregation will not take place. In cases where chutes are impracticable due to excessive drop to placing level, hoppers and sectional tubes (elephant trunks) shall be used.

After the concrete has been placed, it shall be spread, if necessary and thoroughly worked around reinforcement or other embedded fixtures into concrete form and shape. Vibrators shall not be used for pushing the concrete into the adjoining areas. Care must be taken to ensure that the inserts, fixtures, reinforcement and formwork are not displaced during or immediately after the placement and bring the concrete surface out of the alignment beyond tolerance limits, the Owner/Owner's representative may direct to remove the portion and reconstruct or repair the same at the Contractor's expense.

The rate of placement of concrete shall be such that no cold joint is formed and fresh concrete is placed always against green concrete which is still plastic and workable. No concrete shall be placed in open, while it rains. During rainy season, no placement in open is to be attempted unless sufficient tarpaulins or other similar protective arrangement for complete covering the still green concrete from rain is kept at the site of placement. If there has been any sign of washing of cement and sand, the entire affected concrete shall be removed immediately.

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### Compaction

Concrete in general shall be consolidated by vibration using high frequency mechanically driven vibrators. Concrete shall be placed in layers at least 300 mm deep in walls and approximately 450 mm in mass pouring. Vibrators shall not penetrate more than 50 mm into the surface of previously placed layers but shall completely vibrate the working layer. Care shall be taken not to over-vibrate any concrete and especially those with higher slumps. Under no circumstances vibrators shall be attached to or allowed to touch reinforcement. Spare vibrators in good operating condition shall be on hand during placing operations.

### Construction Joints

In general, construction joints shall be limited to those indicated on the drawings. In mass concrete, construction joints may not be indicated in the drawings but shall be made at breaks, offsets or other convenient levels as controlled by volume, plant capacity and time factors. Such construction joints shall be so located that they do not impair the strength of the structure. In walls and columns, height of each lift shall not generally exceed 1.5 m unless otherwise specified in the drawings or directed by the Owner/Owner's representative. Method of forming all construction joints shall conform to the provisions of IS:456.

All construction joints shall be cleaned with wire brush and water to remove all laitance and loose material to expose the aggregates. Immediately before placing fresh concrete, the surface of previously placed concrete shall be coated with a thin coat of cement mortar slurry of the same proportion as that of concrete.


Where locations of the joints are not specified, it will be in accordance with the following:

- a. In a column, the joint shall be formed 75 mm below the soffit of the beam or the edge of the anchored bar of the beam framing into it whichever is lower. The Contractor shall refer to the beam reinforcement drawing before deciding on the location of the joint at column-beam junction.
- b. Concrete in a beam shall preferably be placed without a joint, but if provision of a joint is unavoidable, the joint shall be vertical and at the middle one third of the span, clearing the cross beam location, if any.
- c. A joint in a suspended floor slabs shall be vertical and at the middle one third of the span and at right angles to the principal reinforcement.
- d. In general, construction joints shall be located preferably in a low shear stress zone and at right angles to the direction of the principal stress

Any deviation from the above shall be approved by the Owner/Owner's representative.

### Curing and Protecting

As soon as the concrete has hardened sufficiently, it shall be covered either with Hessian, canvas or similar materials and kept continuously wet for at least seven (7) days after final setting. Curing by continuous sprinkling of water will be allowed if the Owner/Owner's representative is satisfied with the adequacy of arrangements made by the Contractor.

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Curing of concrete with water shall comply with IS:456. Curing compound shall be used subject to approval by the Owner/Owner's representative. Finished floors shall be protected carefully until completely set. Protection of concrete against extreme weather conditions shall comply with the code.

**Finishing**

No touching-up will be permitted to the concrete after removal of formwork. Where damages, honey-combing or other unsatisfactory finishes have occurred to the concrete surfaces, they shall be rectified in a manner as directed by the Owner/Owner's representative, at no extra cost. If in the opinion of the Owner/Owner's representative the concreting is unsatisfactory, demolition of the entire concrete work and reconstruction of the same shall be carried out by the Contractor, as directed by the Owner/Owner's representative at his own cost.

**Formwork & Centering**

Form work in general shall conform to IS: 456.

For complicated work, the Contractor shall submit his proposal of formwork before starting the work for approval of the Owner/Owner's representative. The number of props, their sizes and dispositions shall be such as to be able to safely carry the full dead load and constructional loads. However, approval of the Owner/Owner's representative to this effect shall not relieve the Contractor of his responsibility for proper work and safety.

All forms of beams, slabs and members shall be so designed and erected that the sides can be removed without disturbing the soffit shutter and supports there to.

Beam soffit shall be provided with an upward, camber of 6mm for each 3 m of horizontal span or as directed by the Owner/Owner's representative. Vertical props shall be supported on wedges or sole plates or other measures where by the props can be gently lowered while commencing to remove the shuttering. Columns shuttering shall not be over 1.5 m in height a piece.

Before removal of the shuttering the concrete shall be examined and its removal order taken from the Owner/Owner's representative. In no circumstance shall forms be struck until the concrete reaches strength of at least twice the stress to which the concrete may be subjected at the time of striking.


Shuttering shall not be removed until the number of clear days specified in IS: 456 have elapsed since the last day of placing concrete in the member concerned. All formwork shall be removed without such shock or vibration as would damage the reinforced concrete. Before the soffits and struts are removed, the concrete surface shall be exposed, where necessary, in order to ascertain that the concrete has sufficiently hardened. The specified period may be extended if desired by the Owner/Owner's representative on account of delayed hardening caused by low atmospheric temperature.

**Reinforcement**

The reinforcement bending shall be carried out as per the approved bar bending schedule prepared based on design drawing.

Workmanship shall conform to IS: 2502. All reinforcement shall be free from loose mill scale, rust, oil, grease and paint. Reinforcement shall not be bent or straightened in a manner that will injure the materials and all bars shall preferably be bent cold. Hot bending shall not be permitted for bars whose strength have been increased by cold working.

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Reinforcement bars shall be placed and maintained accurately in positions as shown in the drawings. The correct cover to the reinforcement shall be maintained by use of precast concrete blocks.

All intersections of longitudinal and transverse bars or stirrups and all laps shall be securely tied together with approved binding wire. The binding wire shall be so placed that it touches all the four corners of the intersection and the two ends shall be looped with pliers and the ends shall be turned into the body of the concrete.

Welded joints may be used but in all cases of important connections, tests shall be made to prove that the joints are of the full strength of bars connected. Welding shall be done in accordance with IS:2751 and IS:9417. Butt welding between the ends of a rod in line, whereby stress is transferred across the section may be adopted only for mild steel bars. In case of tack welding for fixing reinforcements in their position, no special precaution need be taken.

**Steel Embedment**

All embedment shall be accurately set, rigidly fastened and suitably anchored by welding lugs. Anchor bolts shall be set to template and firmly secured in vertical and horizontal line and required positions. The guidelines furnished by equipment supplier / vendor shall be taken in to account

Exposed surfaces of embedded materials are to be painted with one coat of red oxide zinc chrome and/ or bituminous paint. Correct location and alignment of all anchor bolts, anchor sleeves, inserts, hangers, conduit pipes and other embedded fixtures as per drawings/instruction shall be entirely the responsibility of the Contractor.

**Expansion & Isolation Joints**


**General**

Expansion and isolation joints in concrete structures shall be provided at specified places, as per details indicated on the drawings. The materials and types of joints shall be as specified hereinafter. In case of liquid retaining structures, additional precautions shall be taken to prevent leakage of liquids as may be specified on the drawings or as directed by the Owner/Owner's representative. All materials are to be procured from reliable manufacturers and must have the approval of the Owner/Owner's representative. Where it is the responsibility of the Contractor to supply the material, the Owner/Owner's representative may demand test certificates for the materials and/or instruct the Contractor to get them tested in an approved laboratory free of cost to the Owner/Owner's representative. Approved samples of the material to be incorporated in the works shall be with the Owner/Owner's representative. Joints shall be formed true to line, level, shape, dimension and quality as per drawings and specifications. Prior approval of the method of forming the joints should be obtained from the Owner/Owner's representative before starting the work.

**Bitumen Board**

Bitumen impregnated fiber board of approved manufacturer as per IS: 1838 may be used as fillers for expansion joints. It must be durable and water proof. It shall be compressible and possess a high degree of rebound. The dimensions of the board should be equal to that of the joint being formed. It should, preferably be manufactured in one piece, matching the dimension of the joint and not prepared by cutting to size smaller pieces from larger boards at site. At the exposed end, the joint shall be sealed with approved sealing compound to a depth of at least 25 mm after application of an approved primer. The sealing compound and the primer shall be applied as specified by the manufacturer.

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### Expanded Polystyrene Boards

If required, commercial quality of expanded polystyrene products commonly used for thermal insulations may also be used as filler material in expansion joints. The thickness may vary from 12 mm to 50 mm. The material will have to be procured from reliable manufacturers as approved by the Owner/Owner's representative. The method of installations will be similar to that recommended by the manufacturers for fixing on cold storage walls. A coat of bitumen paint may have to be applied on the board against which concrete will be placed.

### Joint Filler

The concrete surface shall be made clean, smooth and free from dirt or loose particles. When the surface is completely dry, a coat of hot blow bitumen conforming to IS: 702 of grade 85/25 shall be given with brush or spray. When the bitumen is still hot, the premoulded joint filler fibre board shall be pressed against the surface and held in position till the time it takes to adhere. When more than one layer of filler are specified each layer shall be made to adhere to the preceding layer with a few patches of bitumen between the two layers. After placing the filler in position, the surface of the filler against which further concreting is to be done is given a coat of bitumen.

### Joint sealing compound

Sealing compound shall be of Grade A conforming to IS: 1834. Bitumen shall conform to IS: 3384.

Before application of the sealing compound the sides of the joint are sprayed or brushed with bitumen primer. The primer is then allowed to dry out thoroughly for at least 24 hours and then filled with a mix of 30 % fine sand and 70 % sealing compound by weight.

### Joint Sealing Strips/Water Stops

Joint sealing strips may be provided at the construction, expansion and isolation joints as a continuous diaphragm to contain the filler material and/or to exclude passage of water or any other material into or out of the structure. The sealing strips will be either metallic like GI, Aluminium or non-metallic like PVC.


Sealing strips shall not have any longitudinal joint and shall be procured and installed in largest practicable lengths having a minimum number of transverse joints. The jointing procedure shall be as per the manufacturer's recommendations, revised if necessary, by the Owner/Owner's representative.

### - Metal Sealing Strips

Metal sealing strips shall be either GI or Aluminium and formed straight, U shaped, Z shaped or any other shape and of thickness as indicated in the drawing and/ or as instructed by the Owner/Owner's representative.

The transverse joints will be gas welded using brass rods and approved flux and will be tested by an approved method to establish that it is leak proof. In case it is found that the joints cannot be made leak proof, longer lap length and different method of brazing which will render it leak proof, will be adopted by the Contractor. The edges shall be neatly crimped and bent to ensure proper bond with the concrete.

**GI Strips** : GI Strips shall be minimum 1.5 mm thick and 150 mm in width unless specified otherwise. The standard of Galvanising shall be as per relevant Indian Standards for heavy duty work. The strips shall be strong, durable, without any rust or crease. At the joints, the over-lapping should be for a minimum length of 50 mm.

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**Aluminium Strips** : Aluminium strips shall be minimum 18 swg. thick and 300 mm wide unless specified other wise and shall conform to IS:737 of 19000 grade or 31000 grade (Designation as per IS:6051). A minimum lap of 50 mm length is required at the joints.

It should be cleaned thoroughly before use to expose fresh surface, without any reduction in gauge. A minimum lap of 50 mm is length is required at the joints.

- **Water stops**

This shall be of P.V.C. having any combination of the following features :

- a. Plain
- b. Central bulb
- c. Dumb-bell or flattened ends
- d. Ribbed and Corrugated Wings
- e. V-shaped

Transverse joints will be allowed only under unavoidable circumstances and with the specific approval of the Owner/Owner's representative. The method of forming these joints, laps etc. shall be specified by the Manufacturer and/or as approved by the Owner/Owner's representative, taking particular care to match the central bulbs and the edges accurately.

The minimum thickness of P.V.C water stops shall be 8 mm and the minimum width 150 mm. The actual size and shape will be as shown in drawings and/or as directed by the Owner/Owner's representative. The material should be of good quality Polyvinyl Chloride highly resistant to tearing, abrasion and corrosion as well as to chemicals likely to come in contact with during use. The physical properties will generally be as follows. The actual requirements, which will be directed by the Owner/Owner's representative, may vary slightly. PVC water stops used in water retaining structures shall be able to withstand the water pressure to which it will be subjected to.

**Bitumen Compound**

When directed, the gap in expansion joints shall be thoroughly cleaned and bitumen compound laid as per manufacturer's specifications. The compound to be used shall be of approved manufacturer and shall conform to the requirements of IS: 1834.


**Isolation Joints**

Strong and tough alkathene sheet or equivalent, about 1 mm in thickness and as approved by the Owner/Owner's representative shall be used in Isolation Joints. It shall be fixed by an approved adhesive compound on the cleaned surface on the already set concrete, to cover it fully. Fresh concrete shall be laid against the sheet, care being taken not to damage the sheet in any way.

**Rubber Pad**

Hard foundation quality rubber pads of required thickness and shapes shall be used below machine or other foundation for vibration isolation. The rubber shall have a unit weight of 930 Kg/m<sup>3</sup>, shore hardness - 65 A to 70 A and be of best quality of approved manufacturer, durable, capable of absorbing vibration and must be chemically inert in contact with moist or dry earth or any other deleterious material expected under normal conditions.

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### Precast Concrete

All precast work shall be carried out in a yard for the purpose. This yard shall be dry, properly levelled and having a hard and even surface. If the ground is to be used as a soffit form for the units, it shall be paved with concrete or masonry and provided with a layer of cement plaster with smooth neat cement finish or a layer of M.S. sheeting. Where directed by the Owner/Owner's representative, casting will have to be done on suitable vibrating table. The yard, lifting equipment, curing tank, finished material storage space etc. shall be designed such that the units are not lifted from the mould before seven (7) days of curing and can be removed for erection after twenty eight (28) days of curing. The moulds shall preferably be of steel or of timber lined with G.I. sheet metal. The yard shall preferably be fenced.

Lifting hooks, where necessary or as directed by the Owner/Owner's representative, shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drawings, and shall be removed and the hooks finished after erection if directed by the Owner/Owner's representative.

Precast concrete units, when ready, shall be transported to site by suitable means approved by the Owner/Owner's representative. Care shall be taken to ensure that no damage occurs during transportation. All adjustments, levelling and plumbing shall be done as per instructions of the Owner/Owner's representative. The Contractor shall render all help with instruments, materials and men to the Owner/Owner's representative for checking the proper erection of the precast units. Chipped or cracked or otherwise damaged pre-cast elements will be rejected.

After erection and alignment, the joints shall be filled with grout or concrete as directed by the Owner/Owner's representative. If centerings have to be used for supporting the precast units, they shall not be removed until the joints have attained sufficient strength and in no case before fourteen (14) days. The joint between precast roof planks shall be pointed with 1:2 cement : sand mortar unless otherwise shown in the drawings.

### Waterproofing of Concrete to Structures


#### General

Waterproofing of concrete structures shall be done by suitable extraneous treatments like applying paints, fixing bitumen felts polymeric membrane, installing water bars at construction joints etc.

The design, material and workmanship shall conform to the relevant I.S. codes where applicable. The Owner/Owner's representative's approval of the materials shall be obtained by the Contractor before procurement. If desired by the Owner/Owner's representative, test certificates for the materials and samples shall be submitted by the Contractor. The materials shall be best quality available indigenously, and suitable for the duties called upon.

#### Water Stop

Water bearing structures and underground structures shall have PVC water stops installed at the joints. Installation will be as described under "Expansion & Isolation Joints".

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### Waterproofing Admixtures

#### - In Concrete

The admixture shall be procured from reliable and reputed manufacturers and approved by the Owner/Owner's representative. The method of application and other details shall conform to the manufacturer's specification and/or as instructed by the Owner/Owner's representative.

#### - In Plaster

The concrete surface, to be plastered, shall be hacked to Owner/Owner's representative's satisfaction, cleaned thoroughly and kept wetted for 24 hours. The plaster shall be in cement sand mortar mixed in proportion varying from 1:1 to 1:4 by volume along with the approved waterproofing admixture and laid in appropriate thickness and in layer not exceeding 15 mm or as per manufacturer's specification. The additive shall be of quality and type approved by the Owner/Owner's representative. On completion, the plastered surface shall be cured continuously for a minimum period of fourteen (14) days like concrete.


### Bituminous or Tar Coating

The surface to be waterproofed shall be rendered absolutely dry, clean and dust free. The surface shall be sand papered, cleaned and completely coated with hot coal tar pitch of approved manufacture and quality as per IS:216 (not heated above 375<sup>0</sup>F) using not less than 2 kg./ Sq.m. or with hot asphalt i.e. bitumen according to IS:73 (not heated above 400<sup>0</sup>F) using not less than 1.5 kg per Sq.m. When the first coat has completely dried up and approved by the Owner/Owner's representative, the second coat shall be applied in the same manner using not less than 1.25 Kg. per Sq.m. in case of coal tar and 1 kg per sq m in case of asphalt. Immediately after application of the second coat and before it is dried up, sand shall be spread on the surface to cover it completely. Sufficient time shall be allowed after spreading of sand before backfilling is done in order to allow the final coat to dry up completely.

### Testing Concrete Structures for Leakage

Hydro-static test for water tightness shall be done at full storage level or soffit of cover slab, as may be directed by Owner/Owner's representative, as described below (In compliance with IS: 3370):

- In case of structures whose external faces are exposed, such as elevated tanks, the requirements of the test shall be deemed to be satisfied if the external faces show no sign of leakage or sweating and remain completely dry during the period of observation of seven days after allowing a seven day period for absorption after filling with water.
- In the case of structures whose external faces are submerged and are not accessible for inspection, such as underground tanks, the structures shall be filled with water and after the expiry of seven days after the filling, the level of the surface of the water shall be recorded. The level of water shall be recorded again at subsequent intervals of 24 hrs. over a period of seven days. Backfilling shall be withheld till the tanks are tested. The total drop in surface level over a period of seven days shall be taken as an indication of the water tightness of the structure. The Owner/Owner's representative shall decide on the actual permissible nature of this drop in the surface level, taking into account whether the structures are open or closed and the corresponding effect it has on evaporation losses. Unless specified otherwise, a structure whose top is covered shall be deemed to be water tight if the total drop in the surface level over a period of seven days does not exceed 40 mm. For open type, it shall be 60mm.
- Each compartment/segment of the structure shall be tested individually and then all together.

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For structures such as pipes, tunnels etc. the hydrostatic test shall be carried out by filling with water, after curing as specified, and subjecting to the specified test pressure for specified period. If during this period the loss of water does not exceed the equivalent of the specified rate, the structure shall be considered to have successfully passed the test.

Any leakage that may occur during the hydro-test or subsequently during the defects liability period or the period for which the structure is guaranteed shall be effectively stopped either by cement/epoxy pressure grouting, guniting or such other methods as may be approved by the Owner/Owner's representative. All such rectification shall be done by the Contractor at his own cost to the entire satisfaction of the Owner/Owner's representative.

#### Testing of Materials

##### **Cement**

The Contractor shall submit to the Owner/Owner's representative the manufacturer's certificate for each consignment of cement procured by him. If required by the Owner/Owner's representative's, representative samples shall taken from each consignment and tests for fineness (by hand sieving), setting time and compressive strengths as per IS:269 shall be carried out, free of charge by the Contractor.

##### **Aggregates**

Coarse and fine aggregate and the grading shall be as per IS:383. It shall be free from organic or clay coatings and other impurities, flaky particles, and any other material liable to affect the strength, durability or appearance of concrete. Washing of aggregates by approved means shall be carried out, if desired by the Owner/Owner's representative.

The Contractor shall carry out all the tests on aggregates as may be required by the Owner/Owner's representative in accordance with IS: 2386. The records of these shall be maintained and made available by the Contractor for the checking of Owner/Owner's representative. The acceptance criteria of samples tested shall be in accordance with the requirements of relevant Indian Standards.

##### **Admixture**


###### - **Air Entraining Agents**

Initially, before starting to use Air Entraining Agents, relationship between percentage of air entrained and the cylinder cube crushing strength vis-à-vis quantity of Air Entraining Agents used for all types of concrete will be established by the Contractor free of charge by carrying out sufficiently large number of tests. After that, at regular intervals and whenever directed by the Owner/Owner's representative, the Contractor will check up free of charge, the actual percentage of air entrained and corresponding curing strengths to correlate with the earlier test results.

###### - **Other Admixture**

Tests for establishing the various properties of any other admixtures which may be required to be added shall be carried out by the Contractor free of charge to the Owner/Owner's representative.

Usage of admixtures shall be purely subjected to the approval of Owner/Owner's representative.

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### Concrete

Sampling, curing and testing of specimen will comply with IS: 1199 and IS: 516. Sampling procedure shall generally conform to IS: 456. Sampling frequency for each grade of concrete M20 and above shall be as per relevant IS codes.

In case, the stripping time for shuttering needs to be reduced or early age strength is required to be known in specific cases, the Contractor shall carry out at short notice testing of cubes at one (1) day and three (3) days after accelerated curing as per IS:9013. The required number of additional samples for the same shall also be taken.

To control the consistency of concrete from every mixing plant/machine, slump tests and/or compacting factor tests as per IS:1199 shall be carried out by the Contractor every two hours or as directed by the Owner/Owner's representative in addition to the slump measured when making test cubes.

### Acceptance Criteria

#### Structural Criteria

Acceptance criteria of concrete shall be generally in accordance with IS: 456. Immediately after stripping the formwork, all concrete shall be carefully inspected and any defective work or small defects either removed or made good before the concrete has thoroughly hardened.

The acceptance criteria of concrete shall be in accordance with IS: 456. Concrete work found unsuitable for acceptance shall have to be dismantled and replacement is to be done as per specification by the Contractor. In the course of dismantling, if any damage is done to the embedded items or adjacent structures, the same shall be made good, free of charge by the Contractor, to the satisfaction of the Owner/Owner's representative.

#### Dimensional Criteria

The permissible variation from dimension, lines given in the drawing shall be within tolerances specified below. Wherever tolerances are not specified below the same shall be in accordance with the relevant IS codes/other applicable national/international standards or as indicated by the Owner/Owner's representative.

#### - Tolerances for R.C. Buildings :

i) Variation from the plumb

- In the lines and surfaces of columns, piers, walls and in arises. : 5 mm per 2.5 m or 25 mm, whichever is less


- For exposed corner columns and other conspicuous lines

In any bay or 5 m max. : 5 mm  
In 10 m or more : 10 mm


ii) Variation from the level or from the grades indicated on the drawings

- In slab soffits, ceilings, beam soffit, and in arises

In 2.5 m : 5 mm  
In any bay or 5 m max. : 8 mm  
In 10 m or more : 15 mm

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	-	For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines	
		In any bay or 5 m max.	: 5 mm
		In 10 m or more	: 10 mm
	iii)	Variation of the linear building lines from established position in plan and related position of columns, walls and partitions.	
		In any bay or 5 m max.	: 10 mm
		In 10 m or more	: 20 mm
	iv)	Variation in the size and locations of sleeves, - 5 mm except openings in walls and floors in the case of and for anchor bolts	
	v)	Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls	
		Minus (-)	: 5 mm
		Plus (+)	: 10 mm
	vi)	Footings	
	-	Variation in dimension in plan	
		Minus (-)	: 5 mm
		Plus (+)	: 50 mm
	-	Misplacement or eccentricity	: 2% of footing width not more than 50 mm of misplacement but in the direction
	-	Variation in thickness	
		Minus (-)	: 5% of specified thickness subject to a max. of 50mm
		Plus (+)	: 100 mm
	vii)	Variation in steps	
	-	In a flight of stairs	
		Riser	: 3 mm
		Tread	: 5 mm
	-	Inconsecutive steps	
		Riser	: 1.5 mm
		Tread	: 3.5 mm
	-	Tolerances in other Concrete Structures	
	i)	All structures other than those covered in ii) below.	
	-	Variation of the constructed linear outline from established position in plan	
		In 5 m	: 10 mm
		In 10 m or more	: 15 mm


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- Variations of dimensions to individual structure features from established positions
  - In 20 m or more : 25 mm
  - In buried construction : 50 mm
- Variation from plumb, from specified batter or from curved surfaces of all structures
  - In 2.5 m : 10 mm
  - In 5 m : 15 mm
  - In 10 m or more : 25 mm
  - In buried-construction : Twice the above amounts
- Variation from level or grade indicated on drawings in slab, beams, soffits, horizontal grooves and visible arises
  - In 2.5 m : 5 mm
  - In 7.5 m or more : 10 mm
  - In buried construction : Twice the above amounts
- Variation in cross-sectional dimensions of columns beams, buttresses, piers and similar members
  - Minus (-) : 5 mm
  - Plus (+) : 10 mm
- Variation in thickness of slabs, walls, arch sections and similar members
  - Minus (-) : 5 mm
  - Plus (+) : 10 mm
- ii) Footing for columns, piers, walls, buttresses and similar members
  - Variation of dimension in plan
    - Minus (-) : 5 mm
    - Plus (+) : 10 mm
  - Misplacement or eccentricity  
2% of footing width in the direction of misplacement but not more than 50 mm
  - Reduction in thickness  
5% of specified thickness subject to a max. of 50 mm

Tolerances in other types of structures not covered above shall generally conform to those given in Recommended Practice for Concrete Formwork (ACI 347)

Tolerances in fixing anchor bolts and embedded parts shall be as follows :

- Anchor bolts without sleeves : (±)1.5 mm in plan
- Anchor bolts with sleeves : (±)5.0 mm in elevation
- For bolts upto and including 28 mm dia : (±) 5 mm in all directions
- For bolts 32 mm dia and above : (±) 3 mm in all directions
- Embedded parts : (±)5 mm in all directions

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- Tolerances in precast members
- i) Length
  - Upto 3 m : (±) 6 mm
  - 3 m to 4.5 m : (±) 9 mm
  - 4.5 mm to 6 m : (±) 12 mm
  - Additional for every subsequent 6 m : (±) 6 mm
- ii) Cross Section (Each direction)
  - Upto 50 cm : (±) 6 mm
  - 50 cm to 75 cm : (±) 9 mm
  - Additional for every subsequent 25 cm : (±) 3 mm
- iii) Straightness or bow (Deviation from intended line)
  - Upto 3 m : 6 mm
  - 3 m to 6 m : 9 mm
  - 6 m to 12 m : 12 mm
  - Additional for every subsequent 6 m : 6 mm
- iv) Squareness

When considering the squareness of a corner, the longer of the two adjacent sides being checked should be taken as the base line. The shorter side should not vary in its distance from a perpendicular so that the difference between the greatest and shortest dimensions does not exceed the following limits.

- Length of shorter sides up to and including 1.2 m : 6 mm
- Over 1.2 m but less than 2 m : 9 mm
- 2 m and over : 12 mm

For the purpose of this requirement, any error due to lack of straightness should be ignored; squareness should be measured with respect to the straight lines which are most nearly parallel with the features being checked.

- v) Flatness

The maximum deviations from a 1.5 m straight edge placed in any position on nominally plane surface should not exceed 6 mm.


**STORAGE AND HANDLING OF MATERIALS**

**Cement**

Cement shall be stored in easily countable stacks with consignment identification mark above ground level in perfectly dry and watertight sheds. Bulk cement shall be stored in air tight containers. Cement shall be stored in a manner so as to facilitate removal of first-in first-out basis. Any cement considered defective by the shall not be used by the Contractor and shall be removed from the site immediately. Cement that has been in store for three months or more shall be tested for quality. Should at any time the Owner/Owner's representative has reasons to consider that any cement is defective, then irrespective of its origin, date of manufacture and manufacturer's test certificate,

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**Formwork**

**Design of Formwork**

The design of Form work shall take into account all vertical and lateral loads that the forms will carry or be subjected to, during the construction process. Besides weight and pressure of reinforced concrete and weight of the forms themselves, the design shall consider loadings due to unsymmetrical placement of concrete; impact from dumping of concrete; concentrated loads produced by storing materials on the freshly placed concrete; movement of men and construction equipment; wind action and any other imposed load during construction. Contractor shall assess the magnitude of vertical live load to be taken for design of formwork duly considering his method, sequence and rate of pour of concrete. However, minimum design vertical live load to be considered shall be 750 Kg/m<sup>2</sup> excluding weight of concrete.

Staging for the deck slab shall be supported directly from the TG raft independent of the TG pedestal columns already cast.

Side shuttering shall be designed to cater for concrete pressures, duly considering rate of pour, temperature of concrete, slump and rate of vibration. The column shuttering shall be designed for a rate of vertical pour not less than 4 metres per hour. For shuttering of deck slab of pedestal, the design rate shall not be less than 1.5 metres per hour. Concrete temperature for design purpose shall be taken to be 21°C (or 70°F) or less. Lateral pressures for design of forms shall be based on ACI Committee 622 Pressure Formula or CERA Research Report No.1 Pressure Design Chart. Following Table, based on ACI Committee 622 Pressure Formula, is given as guidance for assessing maximum lateral pressure for design of forms. Pressure in excess of 2400 Kg/m<sup>3</sup> x height of fresh concrete in metres shall not be considered.

Rate of Concrete placement in metre per hour	Maximum lateral pressure in Kg/cm <sup>2</sup> for temperature indicated		
	21° C (70°F)	15° C (60°F)	10° C (50°F)
1.5	3870	4395	5125
1.8	4500	5125	6005
2.1	5130	5860	6885
2.4	5750	6590	7765
3.0	7010	8055	9520
3.6	8265	9520	11280
4.2	9520	10985	13035


**Materials for Formwork**

Scaffolding, props, struts and bracings for the shuttering of TG pedestal shall be of structural steel. Plywood faced shuttering shall be used for achieving smooth exposed concrete finish.

**Wall ties/through bolts**

Through bolts, when used as wall ties, shall be in one single piece for the full length.

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Through bolt diameter and spacing should be designed to cater for entire lateral concrete pressure on the shuttering. In addition, side stays shall be provided to take atleast 50% of the specified design pressure.

Where use of through bolts is not feasible, the entire pressure shall be taken by side stays/props.

Welding of through bolts to reinforcement shall not be permitted.

### Platforms/Windows

Suitable and adequate working platforms shall be provided at TG deck slab level, all round the TG pedestal for easy access for construction and inspection.

Adequate windows at maximum 2 m vertical spacings shall be provided in column shuttering for concreting, inspection and introducing vibrators. Arrangements should be made for closing tightly the windows to prevent loss of water and fine material from concrete, as the pour level overtakes the window level.

### Inserts/Embedment

Inserts/embedment shall not be supported on or tied to reinforcement, but independently on shuttering. If the embedments are to be welded, separate rebars have to be provided for the purpose. Suitable arrangements shall be made to locate and fix them to shuttering. Stools shall be provided where required.

Main equipment foundation bolts, pipe sleeves and block-outs for pockets shall be placed and maintained in position at the top by means of an adequately braced steel template. While planning the template, care should be taken to ensure that it does not block the top of beam and that adequate free space is left to pour concrete from the top.

### Placing of Concrete


Contractor shall furnish to Owner/Owner's representative together with formwork design, his proposed scheme for concreting the TG base raft and pedestal. The scheme shall indicate types of equipment, mobilisation of men and materials, standby arrangements and method, sequence and rate of pouring concrete. Work shall proceed only after Owner/Owner's representative's approval.

Concrete for TG raft and TG deck slab be cooled to a temperature of 23°C and adequate arrangements shall be made to ensure this. Concrete for columns shall be cooled if the least dimensions of column is more than 1.4m.

The base raft shall be cast in not more than two pours or as shown on the drawing. Full raft thickness shall be achieved in each continuous pour. Extent of each pour and sequence of pours shall be as directed by Owner/Owner's representative or as shown in drawing released for construction.

TG pedestal columns from top of base raft to bottom of TG deck etc., shall be cast in one single continuous pour, unless otherwise directed by Owner/Owner's representative or as shown in drawings released for construction.

TG deck slab shall be cast in a single pour without construction joints/cold joints. Successive layers shall be placed before initial set of previous layer or within one hour, whichever is earlier. For proper placement and vibration, the layers shall not be less than 500 mm thick.

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Chutes/tremie pipes of adequate dia (225 mm) shall be used to place concrete if the beams are more than 2 m deep and for this purpose, some top bars will have to be displaced temporarily to allow inserting of the same.

In areas where second stage grouting is to be done after the TG set is erected and aligned, the concrete shall be laid 50 mm higher than the actual level required and chipped back to exact required level. The concrete surface under equipment sole plates shall be ground to ensure a minimum contact area of 85%.

**Tolerances in TG Foundation**

Concreting of TG foundation (raft & pedestal) shall be to following tolerances in horizontal and vertical directions:

- Foundation dimensions : ± 10 mm
- Location of embedded anchor bolts : ± 5 mm
- Location of sleeves for piping and through holes for anchor bolt : ± 10 mm
- Others : As specified in Clause 4.5.0

Technical Specifications for  
"Plain & Reinforced Concrete Work"

**5.5.7 Prestressed Concrete**

**Scope**


This specification covers the requirements in respect design, workmanship and quality of prestressed concrete structures. It is supplementary to and has to be read in conjunction with the specification of plain and reinforced concrete work in Clause 5.5.0.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship and methods & procedures of testing. Some of the relevant available codes are listed hereunder.

- IS : 1343 Code of practice for the prestressed concrete.
- IS : 1785 Specification for plain hard drawn steel wire for prestressed concrete.
- IS : 6003 Specification for intended wire for prestressed concrete
- IS : 2090 Specification for high tensile bars for prestressed concrete.
- IS : 6006 Specification for uncoated stress relieved strand for prestressed concrete.

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## Materials

### Prestressing Steel

Prestressing steel shall conform to IS: 1785, IS: 2090, IS: 6003 and IS: 6006.

### Non-tensioned Reinforcement

Non-tensioned reinforcement may be mild steel bars conforming to IS: 432 or high yield strength deformed bars conforming to IS: 1786.

For other materials refer specification for plain and reinforced concrete work.

### Grades and Proportioning

For prestressed concrete construction, only controlled concrete shall be used. The design of the concrete mix shall conform to the requirements laid down for controlled concrete under relevant clauses of IS: 456, and the workmanship shall conform to specification for cement concrete subject to the following further conditions :

- i) The minimum cube strength of concrete at 28 days where ordinary portland cement is used, and at 7 days where rapid hardening portland cement is used on 15 cm cubes, shall not be less than 45 N/mm<sup>2</sup> for pre-tensioned system and 35 N/mm<sup>2</sup> for post-tensioned systems.
- ii) The mix shall contain not less than 380 kg of cement per m<sup>3</sup> of concrete for pre-tensioned work. The corresponding value of the post-tensioned work shall be 360 kg/m<sup>3</sup> of concrete. The cement in the mix shall not normally exceed 530 kg/m<sup>3</sup> of concrete.
- iii) The mix shall contain as low a water content as consistent with adequate workability.
- iv) The concrete shall be compacted thoroughly by vibration, pressure, shock, spinning or other means and shall have a density of not less than 24 KN/m<sup>3</sup>.


### Workmanship

Workmanship and method of execution shall conform to the requirements of IS: 1343.

The type of jack, like hydraulic jack, etc. used for prestressing shall be standard type and of approved manufacture. The method of anchorage shall be also of approved type so as not to allow more than nominal slip in the wires. The anchorage shall be safe and secure against both dynamic and static loads as well as against impact.

### Testing and Acceptance Criteria

Sampling, strength test and acceptance of precast prestressed members shall be in accordance with the provisions of IS:456 & IS:1343. The Contractor shall conduct load test on one random piece per batch or 1000 units precast. Load test on more than one piece per batch may have to be done if required by the Owner/Owner's representative. The Contractor shall inform the Owner/Owner's representative the number of units that would be cast in a single operation based on which the number of units to be tested will be decided. If a piece/unit fails in a load test the entire batch will be rejected.

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### 5.5.8 Structural Steelwork


#### Scope

This specification covers the requirements in respect of materials, workmanship and quality for preparation of fabrication drawings, supply, fabrication, inspection, testing, painting and erection of structural steelwork including tubular steel work for buildings and structures.

#### Codes and Standards


Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed here under:

IS:800	Code of Practice for use of structural steel in general building construction.
IS:801	Code of Practice for use of cold formed light gauge steel structural members in general building construction.
IS:806	Code of Practice for use of steel tubes in general building construction.
IS:808	Dimensions of hot rolled steel sections.
IS:813	Scheme of symbols for welding.
IS:814	Covered electrodes for metal are welding of structural steel.
IS:815	Classification and coding of covered electrodes for metal are welding of mild steel.
IS:816	Code of Practice for use of metal are welding for general construction in mild steel.
IS:817	Code of Practice for training and testing metal are welders.
IS:818	Code of Practice for Safety and Health requirements in electric and gas welding and cutting operations.
IS:822	Code of Practice for inspection of welds.
IS:919	Recommendations for limits and fits for engineering.
IS:961	Structural Steel (High Tensile).
IS:1148	Hot-rolled rivet bars for structural purposes.
IS:1149	High tensile rivet bars for structural purposes.
IS:1161	Steel tubes for structural purposes.
IS:1200	Method of measurement of steel work and Part VIII iron work.
IS:1239	Mild steel tubes, tubular and other wrought steel fittings.
IS:1363	Hexagon head bolts, screws and nuts of product grade C.

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IS:1364	Hexagon head bolts, screws and nuts of product grade A and B.	
IS:1367	Technical supply conditions for threaded steel fasteners.	
IS:1442	Covered electrodes for metal arc welding of high tensile structural steel.	
IS:1608	Method for tensile testing of steel products.	
IS:1730	Dimensions for steel plate, sheet and strip for structural and general engineering purposes.	
IS:1731	Dimensions for steel flats for structural and general engineering purposes.	
IS:1852	Rolling and cutting tolerances for hot-rolled steel products.	
IS:1977	Structural steel (ordinary quality) St-42-0.	
IS:2062	Weldable structural steel.	
IS:2074	Ready mixed paint, air drying, red oxide zinc-chrome, priming.	
IS:2633	Methods of testing uniformity of coating on zinc coated articles.	
IS:3757	High strength structural bolts.	
IS:4000	High strength bolts in steel structures - Code of Practice.	
IS:5369	General Requirements for Plain Washers and Lock Washers	
IS:5372	Taper washers for channels (ISMC)	
IS:5374	Taper washers for I-beams (ISMB)	
IS:6610	Specification for Heavy Washers for Steel Structures	
IS:6649	Specification for Hardened and Tempered Washers for High Strength Structural Bolts and Nuts	
IS:6623	Specification for High Strength Structural Nuts	
IS:7205	Safety code for erection of structural steelwork.	
IS:7215	Tolerances for fabrication of steel structures.	
IS:9595	Recommendations of metal arc welding of carbon and carbon manganese steels.	
AISC	American Institute of Steel Construction Specification for the Design, Fabrication and Erection of Structural Steel for Buildings.	
SP6(4)	Hand book for use of high strength friction grip bolts.	

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**Materials**

**Structural steel**

All structural steel shall be of tested quality and shall conform to IS:2062. High tensile steel, when supplied, shall conform to IS:961.

**Bolts and nuts**

Bearing bolts and nuts shall conform to IS:1363 and IS:1364 and unless shown or specified otherwise shall be hexagonal. All nuts shall fit tight. Mechanical properties shall conform to IS:1367. High strength friction bolts shall conform to IS:3757 and nuts to IS:6623.

**Washers**

Washers shall conform to IS:5369, IS:5372, IS:5374, IS:6610 and IS:6649 as applicable.

Plain washers shall be made of mild steel, unless otherwise specified. Spring washers shall be provided for those parts which carry dynamic loads and where black bolts for connection are permitted.

**Electrodes**

Mild steel electrodes shall conform to IS:814 and high tensile steel electrodes to IS:1442. The manufactures shall have ISO certification. The Contractor shall furnish to the Owner/Owner's representative a certificate issued by the manufacturer to the effect that the electrodes supplied are in accordance with the above specifications. For welding in any particular position, the electrodes used shall be those recommended by the manufacturer for use in that position.

**Paints**

Paints to be used for shop coat of fabricated steel shall be compatible with the finish coat specified.

**Other Materials**

Other materials used in association with steel work shall comply with the appropriate Indian Standard specifications.


**General requirements regarding supply of materials by Contractor**

Before ordering bought out items, special accessories, equipment etc. and materials of any description, the Contractor shall submit, for the approval of the Owner/Owner's representative, the names of the proposed manufacturers or suppliers together with the specification of the materials and shall, thereafter, send to the Owner/Owner's representative copies of the orders.

When a supplier or sub-Contractor orders materials for the execution of his sub-contract, he shall also comply with the aforesaid requirements, by the submission through the Contractor, for the approval of the Owner/Owner's representative, of the names of the manufacturers proposed and by sending to the Owner/Owner's representative of copies of the orders.

The Contractor shall furnish to the Owner/Owner's representative the following certificates, if required, before commencement of fabrication:

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- i) A certificate stating the process of manufacture and chemical composition of the steel supplied.
- ii) Test certificates by the manufacturer giving the results of each of the specified mechanical tests applied to the structural steel, bolts, nuts and washers and the chemical composition of the same.

**Drawings and Lists**

Unless otherwise stated, the Contractor shall be responsible for the preparation of the detailed fabrication/working drawings, erection and marking plans and all necessary lists such as indents, rivet and bolt lists, material lists, Despatch lists and lists for all bought out items. The fabrication drawings shall indicate the size of each component and length and sequence of all welds & bolted connections.

Fabrication work shall not be taken in hand until the relevant shop drawings have been approved by the Owner/Owner's representative. Although these drawings receive the approval of the Owner/Owner's representative, the Contractor shall be wholly responsible for their being correct and complete. The drawings shall be supplied at least two weeks in advance to enable the Owner/Owner's representative to study the drawings. One copy of the approved drawings will be returned to the Contractor and the work shall be carried out according to the approved drawings.

**Fabrication**

**General**

- **Workmanship**

All workmanship shall be equal to the best practice in modern structural shops. Greatest accuracy shall be observed in the manufacture of every part of the work and all similar parts shall be strictly interchangeable.

- **Templates**

Templates used throughout the work shall be all steel, steel bushed in such cases as the Owner/Owner's representative may consider necessary. In cases where actual materials have been used as templates for drilling similar pieces, the Owner/Owner's representative shall decide whether they are fit to be used as parts of the finished structure.


- **Straightening**

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

- **Clearance**

The erection clearances for cleated ends of members connecting steel to steel should preferably be not greater than 2.0 mm at each end. The erection clearance at ends of beams without web cleats should be not more than 3 mm at each end, but where for practical reasons greater clearance is necessary suitably designed seatings should be provided.

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- **Shearing, flame cutting and planning**

Shearing or flame cutting may be used at the Contractor's option provided that a mechanically controlled cutting torch shall be used for the flame cutting and that the resulting edge shall be reasonably clean and straight. Sheared members shall be free from distortion at sheared edges.

The edges and ends of all flange plates and web plates of plate girders and built-up columns of plates, forming chords or web members of lattice girders and all cover plates, the ends of all angles, tees, channels and other sections forming the flanges of plate girders and columns and chords and web members of lattice girders shall be planed.

The ends of all stiffeners shall be planed or ground to fit tightly between the main angles or flanges. Care shall be taken to ensure a full bearing of the stiffeners at the supports and at other points where concentrated load is applied. The ends shall not be drawn or caulked.

The butting surfaces at all joints of girders or columns shall be planed so as to butt in close contact throughout the finished joint.

The ends of all built-up girders and of all columns shall be faced in a machine. The bearing surfaces of all slabs and plates for caps and bases of columns and for seatings for heavy girders shall be machined.

Unless clean, square and true to shape, all flame-cut edges shall be planed.

Cold sawn ends if reasonably clean and flame cut ends of sections not inferior to sawn ends in appearance need not be planed except for butting ends.

- **Holing**

Holes for black bolts shall be not more than 1.5 mm larger than the nominal diameter of the bolt, unless specified otherwise. All holes, except as stated here under shall be drilled to the required size or sub-punched 3 mm less in diameter and reamed thereafter to the required size. All matching holes for black bolts shall register so that a gauge 1.5 mm less diameter than the hole can pass freely through the members assembled for bolting. All holes for turned and fitted bolts shall be drilled and reamed, if necessary, to a tolerance of only plus 0.13 mm unless specified otherwise. When the number of thicknesses to be riveted exceeds three or the total thickness is 90 mm or more, the holes shall be drilled or reamed in position after assembly, except when steel-bushed jigs are used. The parts shall be firmly bolted together during such block drilling and taken apart for removal of burrs after drilling.

Holes in purlins, side sheeting, runners, packing plates and lacing bars may be punched full size.

All punching and sub-punching shall be clean and accurate and all drilling free from burrs.


No holes shall be made by gas cutting process.

- **Assembly**

All parts assembled for bolting shall be in close contact over the whole surface and all bearing stiffeners shall bear tightly at both top and bottom without being drawn or caulked.

The component parts shall be so assembled that they are neither twisted nor otherwise damaged and specified cambers, if any, shall be provided.

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- **Bolting**

Bolted construction shall be permitted only in the case of field connections, if called for on the drawings and is subject to the limitation of particular connections as may be specified. In special cases, however shop bolt connections may be allowed if directed by the Owner/Owner's representative. Unless otherwise specified, faces of heads and nuts bearing on steel work shall be machined. All such bolts shall be provided with washers having a hole of 1.6 mm larger in diameter than the barrel of bolt and thickness not less than 6.5 mm so that the nut, when tightened, shall not bear on the unthreaded body of the bolt. In all cases, where the full bearing area of the bolt is to be developed, the threaded portion of the bolt should not be within the thickness of the parts bolted together. The threaded portion of each bolt shall project through the nut by at least one thread. Tapered washers shall be provided for all heads and nuts bearing on beveled surface.

- **High Strength Friction Grip Bolting**

Installation of high strength friction grip bolts in joints shall comply with IS:4000 and/or BS:3294. The diameter of the bolt holes must not be more than 2.0 mm larger than the nominal diameter of the bolt. All contact surfaces in a connection including those associated with the bolt heads, nuts and washers, shall be free of scale, burrs, dirt and other foreign matter tending to inhibit uniform sealing of the joint components. However, tight mill scale and the light residual oil coating on bolts, nuts and washers need not be removed.

All fasteners in a joint shall be tightened to a tension equal to or greater than the tension specified in Table 3 of IS: 4000.

Tightening may be achieved by use of Direct tension Indication or part twin method. A hardened washer shall be placed under the element being turned. Bolts shall be tightened at the most rigid portion of the joint, proceeding towards the free edges. Procedure given in IS:4000 shall be followed.

Inspection of friction grip bolting shall ensure that the selected tensioning procedure has been correctly applied and all bolts are fully tensioned. The methods suggested in IS:4000 shall be used to check that all bolts are fully tensioned.


**Welding**

- **General**

The welding and the welded work shall conform to IS: 816 unless otherwise specified. The permissible stresses for welding shall be taken as 75 per cent of those specified in IS:816, where welds are not tested by either radiographic or ultrasonic methods. All butt welds in critical structures such as crane girders, heavy columns, bunkers, etc. shall be tested by either radiographic or ultrasonic methods. As much work as possible shall be welded in shops and the layout and sequence of the operations shall be so arranged as to eliminate distortion and shrinkage stresses to the satisfaction of the Owner/Owner's representative.

- **Plant and equipment**

The plant used shall be of sufficient capacity to suit the welding procedure laid down and be capable of depositing the particular type or types of electrodes to be used under the conditions of current and voltage specified by the electrode manufacturer. The number of welding sets, both automatic and hand operated proposed to be used in the work shop for fabrication of the structural steel work for the contract shall be given by the Bidder along with his tender. Efficient means shall be provided for the accurate indication of the current and in addition, a pair of tong testers shall be supplied by the Contractor and be available to the Owner/Owner's representative.

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All equipment, accessories and connections shall be maintained in proper working order.

- **Electrodes**

All electrodes shall be kept under dry conditions. Any electrode damaged by moisture shall not be used unless it is stated by the manufacturer that when it is properly dried, there will be no detrimental effect. Any electrode which has part of its flux coating broken away or is otherwise damaged, shall be discarded. Any electrode older than 6 months from the date of manufacture shall not be used. Low hydrogen electrodes shall be used for joints in material above 20 mm thick and all important connections.

- **Preparation of Material**

Surface to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign material except that mill scale which withstands vigorous wire brushing may remain. Joint surfaces shall, be free from fins and tears. Preparation of edges by gas-cutting shall, wherever practicable, be done by a mechanically guided torch.

- **Welding procedure**

Before commencement of work the Contractor shall submit to the Owner/Owner's representative for his approval, the procedure proposed to be adopted. The welding procedure shall be arranged to suit the details of the joints as indicated on the drawings and the position at which welding has to be carried out. Welding procedure shall cover the following:


- i) Type and size of electrodes
- ii) Current and (for automatic welding) arc voltage
- iii) Length of run per electrodes, or (for automatic welding) speed of travel
- iv) Number and arrangement of runs in multi-run welds

When necessary the procedure shall also cover the following:

- v) Position of welding
- vi) Preparation and set up of parts
- vii) Welding sequence
- viii) Pre or post heating
- ix) Any other relevant information

- The welding procedure shall be so arranged that the distortion and shrinkage stresses are reduced to a minimum and that the welds meet the requirement of quality specified here under.

- The Contractor shall record the approved welding procedure and shall provide each operator with all relevant details. Alternative approved procedure may be furnished in such cases when it is desirable to make the fullest use of available plant. The welding procedure then laid down shall be strictly followed and no variation shall be permitted without the approval of the Owner/Owner's representative.

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- Preening of the welds involving deformation of the weld surface either during deslagging operation or thereafter, shall not be allowed.

**Fusion faces and surrounding surfaces:**

- Fusion faces and the surrounding surfaces within 50 mm of welds shall be free from all mill scale and free from oil, paint, or any substance which might affect the quality of the weld or impede the progress of welding. They shall be free from irregularities such as would interfere with the deposition of the specified size of weld or be the cause of defects.
- All mill scale within 50 mm of welds shall be removed prior to welding either by pickling at works followed by thorough power wire brushing or by other approved methods.
- If preparation or cutting of the fusion faces is necessary the same shall be carried out by shearing, chipping, gas-cutting or flame-gouging.
- Where hand gas cutting or hand-gouging is employed, the blow pipe or gouging blow pipe shall be properly guided.

**Assembly for welding:**

Parts to be welded shall be properly assembled and held firmly in position by means of jigs and clamps prior to and during welding.

The fit of joints at contact surfaces which are not completely sealed by welds, shall be close enough to exclude water after painting. Abutting parts to be butt-welded shall be carefully aligned. Misalignments greater than 3 mm or 25% of the thickness of thinner plate whichever is smaller shall be corrected and in making the correction the parts shall not be drawn into a sharper slope than two degrees (2 deg).

The work shall be positioned for flat welding whenever practicable.

**Welding Sequence**

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as will avoid needless distortion and minimise shrinkage stresses. Where it is impossible to avoid high residual stresses in the closing welds of a rigid assembly, such closing welds shall be made in compression elements.


In the fabrication of cover-plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the member. Long girders or girder sections may be made by shop splicing not more than three sub-sections, each made in accordance with this paragraph.

When required by the Owner/Owner's representative, welded assemblies shall be stress relieved by heat treating in accordance with the provisions of the relevant Indian Standard or any other Standard approved by the Owner/Owner's representative.

**Welding technique**

All complete penetration groove welds made by manual welding, except when produced with the aid of backing material not more than 8 mm thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged out on the back side before welding is started from that side, and shall be so welded as to secure sound metal and compact fusion throughout the entire cross-section. Groove welds made with the use of a backing of the same material as the base metal shall have the weld metal thoroughly fused with the backing

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material. Backing strips need not be removed. If required, they may be removed by gouging or gas cutting after welding is completed, provided no injury is done to the base metal and weld metal and the weld metal surface is left flush or slightly convex with full throat thickness.

Groove welds shall be terminated at the ends of a joint in a manner that will ensure their soundness. Where possible, this should be done by use of extension bars or run-off plates. Extension bars or run-off plates need not be removed upon completion of the weld unless otherwise specified elsewhere in the specifications.

The effective area of fillet welds shall be considered as the effective length times the effective throat thickness. The effective length of fillet welds except fillet welds in holes and slots shall be the overall length of full size fillet, including returns.

The effective throat thickness of a fillet weld shall be the shortest distance from the root to the face of the diagrammatic weld.

The minimum size of weld is determined by the thicker of the two parts joined except that the weld size need not exceed the thickness of the thinner part joined unless a larger size is required by calculated stress. For this exception, particular care shall be taken to provide sufficient preheat for soundness of the weld. The minimum size of fillet welds are as follows.

Material thickness of thicker part joined	Minimum size of fillet weld	Minimum effective throat thickness of partial penetration groove welds
Upto 6 mm	3 mm	3 mm
6mm to 12 mm	5 mm	5 mm
12 mm to 19 mm	6 mm	6 mm
19 mm to 38 mm	8 mm	8 mm
38 mm to 57 mm	8 mm	10 mm
57 mm to 152 mm	8 mm	13 mm
Over 152 mm	8 mm	16 mm

The minimum effective length of a fillet weld designed on the basis of strength shall not be less than 4 times the nominal size (of weld) or else the size of the weld shall be considered not to exceed 1/4 of the effective length.


In intermittent welds the effective length of any segment of intermittent fillet welding shall be not less than 4 times the weld size with a minimum of 40 mm.

The minimum amount of lap on lap joints shall be 5 times the thickness of the thinner part joined but not less than 25 mm.

Side or end fillet welds terminating at ends or sides respectively of parts or members shall wherever practicable, be returned continuously around the corner for a distance not less than 2 times the nominal size of weld.

To get the best and consistent quality of welding, automatic submerged arc process shall be preferred. The technique of welding employed, the appearance and quality of welds made, and the methods of correcting defective work shall all conform to the relevant Indian Standards.

Preheating techniques combined with the use of low hydrogen electrodes shall be used for

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- i. Certain joint configurations as specified in the drawings and as directed by the Owner/Owner's representative.
- ii. Welding involving plates over 20 mm thickness conforming to IS:2062.
- Temperature

No welding shall normally be done on parent material at a temperature below (-) 5 deg C. However, if welding is to be undertaken at low temperatures, adequate precautions as recommended in relevant Indian Standard shall be taken. When the parent material is less than 40 mm thick and the temperature is between (-) 5 deg C and 0 deg C, the surface around the joint to a distance of 100 mm or 4 times the thickness of the material, whichever is greater, shall be pre-heated till it is handwarm. When the parent material is more than 40 mm thick, the temperature of the area mentioned above shall in no case be less than 20 deg C. All requirements regarding preheating of the parent material shall be in accordance with the relevant Indian Standard.

The table below may be used as a guideline for preheat and interpass temperature to be maintained within 75 mm on either side of the point of welding.

Thickness of the thickest part at the point of welding other than low hydrogen welding electrodes	Minimum preheat & Interpass temperature	
	Low hydrogen welding electrodes	
Upto 20 mm	None	None
20 mm to 40 mm	65°C	20°C
40 mm to 63 mm	110°C	65°C
Over 63 mm	150°C	110°C

- **Accuracy of fit up:**

Parts to be fillet welded shall be brought into as close contact as practicable and the gap due to faulty workmanship or incorrect fit up shall not exceed 1.5 mm. If greater separation occurs at any position, the size of fillet weld shall be increased at such positions by the amount of the gap.

- **Jigs and manipulators:**


Jigs and manipulators shall be used where practicable and shall be designed to facilitate welding and to ensure that all welds are easily accessible to the operators.

- **End of butt welded joints:**

The ends of butt joints shall be welded so as to provide the full throat thickness. This may be done by the use of extension pieces, cross-runs or other means approved by the Owner/Owner's representative.

- **Weld face and reinforcement of butt welds:**

The weld face shall at all places be deposited proud of the surface of the parent metal. Where a flush surface is required the surplus metal shall be dressed off.

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- **Minimum leg length and throat thickness in fillet welds:**

The minimum leg length of a fillet weld as deposited shall be not less than specified size. In no cases shall a concave weld be deposited without specific permission of the Owner/Owner's representative. Where permitted, the leg length shall be increased above that specified, so that the resultant throat thickness is as great as would have been obtained by the deposition of a flat-faced weld of the specified leg length.

- **Deslagging:**

After making each run of welding all slag shall be thoroughly removed.

- **Quality of welds:**

The weld metal, as deposited (including tack welds if to be incorporated) shall be free from cracks, slag inclusions, gross porosity, cavities and other deposition faults. The weld metal shall be properly fused with the parent metal without serious undercutting or overlapping at the toes of the weld. The surface of the weld shall have a uniform consistent contour and regular appearance.

- **Working conditions:**

Welding shall not be done under weather or other conditions which might adversely affect the efficiency of the welding and where necessary effective protection or other safeguard shall be provided.

- **Qualification and testing of welders:**

The Contractor shall satisfy the Owner/Owner's representative that the welding operators are suitable for the work upon which they will be employed and shall produce evidence to the effect that welders have satisfactorily completed appropriate tests as described in IS:817. The Owner/Owner's representative may at his discretion order periodic tests of the welders and/ or of the welds produced by them. Such tests shall be at the expense of the Contractor.

- **Supervision:**


The Contractor shall employ a competent welding supervisor or charge-hand to ensure that the standard of workmanship and the quality of the materials comply with the requirements laid down in this specification.

**Machining of butts, caps and bases**

Column splices and butt joints of struts and compression members depending on contact for stress transmission shall be accurately machined and close butted over the whole section with a clearance not exceeding 0.2 mm locally. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc. after rivetting, bolting and/ or welding together as the case may be, should be accurately machined so that the parts connected butt over the entire surfaces of contact. Care should be taken that those connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 2.0 mm.

Where sufficient gussets and bolts or welds are provided to transmit the entire loading or where connection is by full penetration butt welds, the column ends need not be machined.

Slab bases and caps, if applicable, shall be in one solid piece, and except when cut from material with surfaces, and shall be accurately machined over the bearing surfaces and shall be in effective contact over the whole area of the machined end of the stanchion. A bearing face need not be

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machined if it is to be grouted directly to a foundation provided it is true and parallel to the machined face. To facilitate grouting, holes shall be provided where necessary in stanchion bases for escape of air.

**Shop painting**

The whole of steel work with the exception of bolts and nuts and machined surfaces after being thoroughly cleaned to remove rust, loose scale, grease, dust etc. shall be given one shop coat of primer compatible with the finish paint. For epoxy based paints, surface preparation shall be by sand blasting. All rivets, bolts, nuts and washers etc. shall be thoroughly cleaned and dipped in boiled linseed oil. All machined surfaces shall be well coated with a mixture of white lead and tallow. Surfaces which are to be held in contact by bolting shall be painted before assembly, and the parts brought together while still wet. Unless specified otherwise, all surfaces inaccessible after bolting or intermittent welding shall be given two coats of approved paint before assembly. In the case of surfaces to be welded, the steel shall not be painted or metal coated within a suitable distance of any edges to be welded if the paint specified or the metal coating would be harmful to welders or impair the quality of the welds. Welds and adjacent parent metal shall not be painted prior to deslagging, inspection and approval. Parts which are to be encased in concrete shall not be painted or oiled.

**Marking, packing and despatching**

Each piece shall be distinctly marked before delivery, in accordance with an approved marking diagram and shall bear such other marks as will facilitate erection. For easy identification at site, a small distinguishing mark for each building shall be painted on each end of every member before despatch from fabrication shop. The fabricated steel work shall be despatched in such portions as may be found convenient for erection or as ordered by the Owner/Owner's representative.

All projecting plates or bars and all ends of members at joints shall be stiffened, all straight bars and plates shall be bundled, all screwed ends and machined surfaces shall be suitably packed and all rivets, bolts, nuts, washers and small loose parts shall be packed separately in cases so as to prevent damage or distortion during transit.

**Erection**

**General**

The material shall be verified with marking on the marking plan or shipping lists which shall be supplied by the Contractor.


Any material found damaged or defective shall be stacked separately and the damaged or defective portions be painted in distinct colour. Such material is to be dealt with under the orders of the Owner/Owner's representative without delay.

The field assembling of the component parts of a structure shall involve the use of method and appliances not likely to produce injury by twisting, bending or otherwise deforming the metal. No member slightly bent or twisted shall be put in place until the defects are corrected and members seriously damaged in handling shall be rejected.

All small bends or twists received by members shall be rectified before such members are put in place; any serious bends or damage shall be reported at once to the Owner/Owner's representative by the Contractor for instructions. The straightening of bent edges of plates, angles and other shapes shall be done by methods not likely to produce fracture or other injury.

Following the completion of the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of incipient or other fractures.

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**Setting Out**

The Contractor shall assume full responsibility for the correct setting out of all steel work and erecting it correctly as per alignment and levels shown on the drawings and plumbing of vertical members. Datum points will be fixed by the Owner/Owner's representative near the work site. Notwithstanding any assistance rendered to the Contractor by the Owner/Owner's representative, if at any time during the progress of the work any error should appear to arise therein, on being required to do so, the Contractor at his own cost shall remove and amend the work to the satisfaction of the Owner/Owner's representative.

**Field connections**

All field connections in the trusses, columns, girders, framework etc. shall be welded, unless otherwise specified. Connection of purlins, girts and other unimportant members only may be bolted with black bolts, except where welded connections are required.

Use of "high strength friction grip" bolts in place of welding may be permitted for field connections at the discretion of the Owner/Owner's representative.

**Field bolting**

All relevant portions in respect of bolted construction of the Specification for Fabrication of Structural Steel work shall also be applicable for field bolting in addition to the following.

Bolts shall be inserted in such a way so that they may remain in position under gravity even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled, all joint surfaces, including those adjacent to the washers, shall be free of scales except tight mill scales. They shall be free of dirt, loose scales, burns, and other defects that would prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil, paint, lacquer, or galvanising.

All high tensile bolts shall be tightened to provide, when all fasteners in the joint are tight, the required minimum tension by any of the following methods.


**Turn-of-nut method**

When the turn-of-nut method is used to provide the bolt tension, there shall first be enough bolts brought to a "snug tight" condition to ensure that the parts of the joint are brought into good contact with each other. "Snug tight" is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench: Following this initial operation, bolts shall be placed in remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable amount of nut rotation specified in Table I with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation, there shall be no rotation of the part not turned by the wrench.

TABLE-I

Bolt length exceeding	Remark
8 times diameter or 200 mm	
2/3 turn	Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. Tolerance on rotation- 30° over or under

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Bolts may be installed without hardened washers when tightening is done by the turn-of-nut method.

Bolts-tightened by the turn-of-nut method may have the outer face of the nut match-marked with the protruding bolt point before final tightening, thus affording the inspector visual means of noting the actual nut rotation. Such marks can be made by the wrench operator by suitable means after the bolts have been brought up snug tight.

**Torque wrench tightening**

When torque wrenches are used to provide the bolt tensions, the bolts shall be tightened to the torques specified in Table-II. Nuts shall be in tightening motion when torque is measured. When using torque wrenches to install several bolts in a single joint, the wrench shall be returned to "touch up" bolts previously tightened, which may have been loosened by the tightening of subsequent bolts, until all are tightened to the required tension.

**TABLE-II**

Nominal Bolt Diameter (mm)	Torque to be applied (Kg.M) for Bolt class 8.8 of IS:1367
20	56.93
22	81.63
24	103.73

In either case of the above two methods if required, because of bolt entering and wrench operation clearances, tightening may be done by turning the bolt while the nut is prevented from rotating.

Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately ten seconds.

Holes for turned bolts to be inserted in the field shall be reamed in the field. All drilling and reaming for turned bolts shall be done only after the parts to be connected are assembled.

Tolerances applicable in the fit of the bolts shall be in accordance with relevant Indian Standard Specifications. All other requirements regarding assembly and bolt tightening shall be in accordance with this Sub-Clause.


**Field welding**

All field assembly and welding shall be executed in accordance with the requirements for shop fabrication, excepting such as manifestly apply to shop conditions only. Where the steel has been delivered painted, the paint shall be removed before field welding, for a distance of at least 50 mm on either side of the joints.

**Bedding and grouting**

Bedding shall be carried out with cement grout or mortar having a compressive strength of 250 kg per sq. cm at 28 days for main column bases and 200 kg per sq. cm at 28 days for secondary column bases. For the main column the Contractor shall provide screed bars of mild steel flats and fix them in mortar. The Owner/Owner's representative will be the sole authority in deciding "main"

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and "secondary" columns and his decision in this matter will be binding on the Contractor within the terms of this contract.

The bedding shall not be carried out until a sufficient number of columns has been properly aligned, levelled and plumbed and sufficient girders, beams, trusses and bracings are in position to the satisfaction of the Owner/Owner's representative. Immediately before grouting, the space under the base plate and around bolts shall be thoroughly cleaned and made free from excessive moisture.

The grout or mortar shall be mixed as thick as possible consistent with fluidity and shall be poured under pressure with pressure grouting machine, until the space has been filled with mortar. Admixtures, if directed to be added will be measured and paid separately. If desired, ready mix high strength non-shrink grout of specified strength shall be used.

**Painting after erection**

Before painting of steel which is delivered unpainted is commenced, all surfaces to be painted shall be dry and thoroughly cleaned of all loose scale, rust, dust, grease, etc.

The specified protective treatment shall be completed after erection. All rivet and bolt heads and the site welds after deslagging shall be cleaned. Damaged or deteriorated paint surfaces shall be made good first with the same type of paint as the shop coat. Where specified, surfaces which will be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet.

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

Site painting should not be done in frosty or foggy weather or when humidity is such as to cause condensation on the surface to be painted.

Two or more final coats of approved paint as specified shall be applied to the steel work after erection.

Correction of misfits

Correction of minor misfits, a reasonable amount of reaming and cutting of excess-stock from rivets will be considered a legitimate part of the erection.

Any error in shop work which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or a moderate use of reaming and slight chipping or cutting shall immediately be reported to the Owner/Owner's representative and his approval of the method of correction obtained.

**Testing and Acceptance Criteria**


**General**

The Owner/Owner's representative shall have free access at all reasonable times to those parts of the manufacturer's works which are concerned with fabrication of the steel work and shall be afforded all reasonable facilities for satisfying himself that the fabrication is being undertaken in accordance with the provisions of this specification.

Unless specified otherwise, inspection shall be made at the place of manufacture prior to despatch and shall be conducted so as not to interfere unnecessarily with the operation of the work.

Tolerance for fabricated structures shall be as per IS:7215.

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Should any structure or part of a structure be found not to comply with any of the provisions of this specification, it shall be liable to rejection. No structure or part of the structure, once rejected shall be resubmitted for test, except in cases where the Owner/Owner's representative considers the defect as rectifiable.

Defects which may appear during fabrication shall be made good with the consent of and according to the procedure laid down by the Owner/Owner's representative.

All gauges and templates necessary to satisfy the Owner/Owner's representative shall be supplied by the manufacturer.

The Owner/Owner's representative may, at his discretion, check the test results obtained at the manufacturer's works by independent tests at the Government Test House or elsewhere.

When all tests to be performed in the Contractor's shop under the terms of this Contract have been successfully carried out, the steel work will be accepted forthwith and the Owner/Owner's representative will issue an acceptance certificate, upon receipt of which, the items will be shop painted, packed and despatched. No item is to be delivered unless an acceptance certificate for the same has been issued. The satisfactory completion of these tests or the issue of the certificates shall not bind the Owner/Owner's representative to accept the work, should it, on further tests before or after erection, be found not in compliance with the Contract.

**Tolerances**

- **Fabrication**

Tolerances for fabrication of structures shall be generally as per IS:7215.

In particular the acceptable fabrication tolerances for various parameters are given below:

- **Length**

- Length of strut finished for tight bearing contact : (±) 1 mm
- Length of any other member upto and including 12 m : (+) 0, (-)3.0 mm
- Length of any other member over 12 m : (+) 0, (-)0.00025 L subject to a max. of (-)5.0 mm

- **Width**

- Width of built-up girders (plate girders) : (±) 3 mm
- Deviation in the width of members required to be inserted in other member : (+) 0, (-)2 mm


- **Depth**

- Depth of girders (measured at centreline of web) for depths upto 4 m : (+) 3, (-)2 mm
- -do- for depths over 4 m : (+) 4, (-)3 mm

- **Sweep, Camber**

- Deviation from straightness in plan (Sweep) : 0.001 L subject to max. of 10 mm

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- Deviation in elevation convexity (Camber) : (+) 5 mm, (-) 0
- Deviation of centreline of web from centreline of flanges in built-up members at contact surfaces : 3 mm
- Deviation from flatness of plate webs of built-up members in a length equal to the depth of the member : 0.005 d subject to max. of 10 mm

**Tilt of flange of plate girders**

- at splices & stiffeners, at supports, at the top flanges of crane girders, at bearings : 0.005 b subject to max. of 2 m
- at other places : 0.015 b subject to max. of 4 mm
- Deviation from squareness of flange to web of box columns and box girders : (±) 3 mm
- Deviation from squareness of fixed base plates to axis of column. This dimension shall be measured parallel to the longitudinal axis of the column at points where the outer surfaces of the column sections make contact with the base plate
- Deviation from squareness of machined ends to axes of columns : 0.5 mm
- Deviation from squareness of machined ends to axes of beam or girder : 0.6 mm


In addition to the above tolerances, the fabrication of crane girders shall comply with the following:

- Top flanges shall be as flat as possible and the cross camber over the central width of 150 mm shall not exceed 0.6 mm with the convex surface upwards. Crane girder with a concave surface over the central width of 150 mm will not be accepted.
- Webs will be flat and straight and shall not vary from the intended line by more than 2 mm measured at the top flange.
- Gantry girders shall be straight with SWEEP not exceeding 3 mm in 12 m length of the girder. CAMBER shall not exceed 3 mm in 12 m length.
- The tolerance on the overall depth of crane girders without their bearings shall be (±) 2 mm.

**Acceptance**


Should any structure or part of a structure be found not to comply with any of the provisions of this specification, the same shall be liable to rejection. No structure or part of the structure, once rejected, shall be offered again for test, except in cases where the Owner/Owner's representative considers the defects rectifiable. The Owner/Owner's representative may, at his discretion, check the test results obtained at the Contractor's works by independent tests at an approved laboratory.

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**Erection**

- Columns
- Shifting of column axis at foundation with respect to building both in longitudinal & lateral direction : (±) 3 mm
- Out of plumbness (verticality) of column axis from true vertical axis as measured at column top
- For column upto 10 m height : (±) 5 mm
- For column exceeding 10 m 10 m height : (±) 1/2000 of column height but not more than 15 mm
- Deviation in the level of bearing surface of columns at foundation top with respect to true level : (±) 3 mm
- Deviation in bearing levels for beams, trusses . etc. with respect to true level : (±) 3 mm
- Difference in bearing level between adjacent column both across and along the building : (±) 6 mm
- Difference in erected position at adjacent pairs of columns along the length or across the width of building prior to connecting trusses/beams with respect to true distance : (±) 10 mm
- Trusses/Beams
- Deviation at Centre of span of upper chord from vertical plane running through of truss or of chord and perpendicular to plane at truss/beams : 1/250 of depth member 20 mm whichever is less
- Lateral displacement of top chord at centre of span from vertical plane running through centre of supports : 1/1500 of the span or 10 mm whichever is less
- Lateral shift in location from it true line of purlin/beam : (±) 5 mm
- Crane Girders & Rails
- Difference in levels of crane girder/crane rails measured between adjacent columns : 5 mm
- Difference in levels of crane rails (across the building)
- Over the supports : 10 mm
- At the mid span of girders : 15 mm

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- Difference in level of flange of successive girders at connection : 1 mm
- Deviation in the crane rail level at any point from true level : (±) 5 mm
- Difference in crane rail actual levels between any two points 2 m apart along the rail length : 2 mm
- Relative shift of crane rail surfaces at a joint in plan and elevation : 2 mm subject to grinding of Surfaces for Smooth transition
- Relative shift in the location of crane stops (end buffers) along the crane tracks : 1/1000 of track gauge to a max. of 20 mm
- Deviations of crane rail axis from centerline of web : (±) 3.5 mm
- Deviations in alignment of crane rail in plan measured between any two points 2 m apart : 1 mm
- Deviation in crane rail gauge : 5 mm

### 5.5.9 Brickwork & Plastering

#### Scope


This specification covers the requirements in respect of materials, workmanship and quality for brickwork and plastering.

#### Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Indian Standards Institution and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

#### Brick work

- IS:1077 Common burnt clay building bricks
- IS:1542 Sand for plaster
- IS:1661 Code of practice for application of cement and cement-lime plaster finishes
- IS:2166 Sand for masonry mortars
- IS:2212 Code of practice for brickwork
- IS:2250 Code of practice for preparation and use of masonry mortars
- IS:2691 Burnt clay facing bricks

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- IS:3495      Methods of tests of burnt clay building bricks
- IS:3696      Safety code for scaffolds and ladders
- IS:5454      Methods of sampling of clay building bricks

**Materials**

**Cement**

Cement used shall conform to IS:269, IS:455 or IS:1489

**Sand**

The sand shall be approved river or pit sand and it shall conform to IS:2116 for masonry mortar and to IS:1542 for plaster mortar.

**Bricks**

The bricks used shall be at least chamber burnt second class (class B) bricks conforming to IS:1077 having a minimum compressive strength of 35 kg/cm<sup>2</sup>. Bricks are to be whole, uniform texture, sound, well burnt, free from cracks, square and well shaped, uniform in size, uniform red cherry or copper colour and shall emit a clear ringing sound when struck. Slight distortion or rounded edges are permitted provided no difficulty arises during laying of uniform course.

Water absorption after 24 hours immersion shall not exceed 20% by weight. Dimensional tolerance shall not exceed 8%. Laboratory test has to be conducted to ascertain the same. Representative samples shall be submitted and approved samples shall be retained by the Owner/Owner's representative for future comparison.

**Storage and Handling**

Bricks shall not be dumped at site. These shall be stacked in regular tiers on firm ground, even as these are unloaded, to minimize breakage and defacement of bricks. Bricks selected from different situation of use in the work shall be stacked separately. The broken bricks shall not be used in the masonry and shall be separated from the lot being used for masonry works.

**Workmanship**

**Brick work**


The whole of the brickwork shall be carried out by the Contractor in a uniform manner.

All the bricks shall be kept under water till they are completely soaked and used on the works on their becoming skin dry.

The Contractor shall set out and build all brickwork to the dimension, thickness and heights shown on the drawings. The Contractor shall build all brickwork in English bond and half brick walls and casing to pipe, chases etc in stretcher bond. Brickbats shall not be used except where required for bond.

The Contractor shall lay bricks in full mortar beds with shoved joints. The joints are not to exceed 10 mm in thickness and are to be full of mortar, close, well finished and neatly struck. The vertical joints in any course shall not be nearer than quarter of a brick length from those in the course below. All joints shall be of same width except for small variations to maintain bond. The brickwork

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shall be laid plumb and trim to line and level. No portion of brickwork shall be raised more than 1 metre above another at one time. If the mortar in any course has begun to set, the joints shall be raked out before another course is laid. The top course of brickwork in reinforced concrete framed structure shall be wedged against reinforced concrete surface and joint well filled with mortar.

The Contractor shall flush up thoroughly with mortar all joints as the work proceeds. Where brickwork is to receive plaster, the joints shall be raked to a depth of 12 mm to provide proper bond.

The brickwork as it progresses shall be thoroughly watered on its faces and top. New work shall be properly bonded with the old work. The surface of unfinished work shall be cleaned and thoroughly wetted before joining new work to it.

Any work in which the mortar perishes shall be dismantled and rebuilt by the Contractor at his own expense.

The Contractor shall carry out work in as clean a manner as possible and shall remove excess material and mortar droppings daily.

Where brick walls, are to receive plaster, excess materials and mortar droppings shall be removed and the surface shall be brushed clean.

During cleaning operations, adjacent work shall be protected and any damage resulting from improper protection shall be made good by the Contractor at his own cost.

Reinforcement if shown in the drawing shall be provided fully embedding in mortar after thoroughly cleaned. These shall be lapped with dowels if left in RC columns or welded to steel columns.

Encasing of structural steel shall be done by building masonry work round flanges, webs etc., and filling the gap between steel and masonry by minimum 12 mm thick mortar. Encased members shall be wrapped with chicken wire mesh when shown on drawings or instructed by the Owner/Owner's representative. The minimum lap in chicken wire mesh shall be 50 mm. Other steel embedment shall be generally embedded in mortar and masonry unit shall be cut as required.

### Plastering


Unless otherwise specified, all plaster work shall be carried out according to IS:1661. The thickness and proportion of cement plaster shall be as specified in the drawing.

The surface to be plastered shall be cleaned of all extraneous matter and rubbish. In brickwork the joints shall be raked and concrete surface roughened by chipping or hacking. Any shuttering material adhering to the concrete shall be removed. The Contractor shall make plaster pads of the required thickness of plaster for correctness of plumb, line and level. The surface shall be thoroughly watered and soaked and aerated and all holes shall be closed before starting plastering operation.

Plaster, when more than 15 mm thick shall be applied in two coats - a base coat followed by the finishing coat. Thickness of under coat shall be of sufficient to fill up all unevenness in the surface, no single coat, however, shall exceed 15 mm in thickness.

For one coat plaster work, the plaster shall be laid slightly thicker than the specified thickness and the surface then levelled with flat wooden rule to the required thickness. The plaster shall be well pressed into the joints and the surface finished as specified.

For two coats of plaster work, the first coat shall be applied as described above except that the surface shall be left rough and keys formed for the application of second coat. The second coat shall be applied a day or two after the first coat has set, but the first coat shall not be allowed to dry.

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The second coat shall consist of mortar ground very fine and shall be laid on with a wooden rule to a specified thickness, rubbed smooth and levelled and the surface plastered completely the same day. The levelling shall be continued till the plaster is quite dry and all moisture which exudes from the plaster shall be wiped off with a fine cloth. The surface shall be kept dry until exudation of moisture ceases, during the process of rubbing.

**Finish**

- **Sand faced plaster**

The plaster shall be applied in two coats. The first coat or the scratch coat should be approximately 14 mm and shall be continuously carried out without breaks to the full length of wall or up to doors, windows etc. The scratch coat shall be dashed on the prepared surface with heavy pressure, brought to true and even surface and then lightly roughened by cross scratch lines to provide bond for finish coat. The scratch coat shall be cured for at least 7 days and then allowed to dry.

The second coat shall be 6 mm thick and it shall not be applied until at least 10 days have elapsed after the application at second coat. Before application of the second coat, the scratch coat shall be evenly damped. This coat shall be applied from top to bottom in one operation and without joints, finish shall be straight, true and even. Only approved river sand shall be used for the second coat and for finishing work. Sand for finish shall be of even coarse size and shall be dashed on the surface and sponged.

- **Plaster-of-Paris Punning**

Plastered surfaces, where specified, shall be finished with plaster-of-paris punning. The thickness of punning shall be 2 mm and shall be applied by skilled workman. The finish shall be smooth, even and free from undulation. Before bulk work is taken in hand, a sample of punning shall be done on roughly 1 sq.m area and approval of the Owner/Owner's representative taken. The work shall be taken then in hand as per approved sample.

**Curing**

The brick shall be cured for a period of fourteen (14) days after laying and the plaster shall be cured for a period of seven (7) days.

**Expansion & Separation Joints**


Location and details of expansion joints shall be strictly as shown in the drawings. Expansion joint filler boards and sealing strips shall have minimum transverse joints. Transverse joints shall be approved by the Owner/Owner's representative.

Separation joints shall be with standard water proof paper or with alkathene sheets about 1 mm in thickness. Length and sealing of laps shall be to the satisfaction of the Owner/Owner's representative.

**Damp Proof Course**

The proportion of cement to aggregates shall be 1:2:4 using 6 mm down stone chips with a water proofing admixture. The percentage of waterproof admixture shall be as per manufacturer's specification but not less than 1% by weight of cement. The brick masonry surface shall be levelled, flushed up and prepared as directed to receive the damp-proof course. The thickness of damp proof course shall be 40 mm. In masonry walls of buildings it shall normally be placed above the external ground level. It shall be laid for the full width of the wall. The top surface shall be kept rough or ribbed for mortar for brickwork coming over it, for proper adhesion. All exposed surfaces of the damp-proof course shall be finished fair and smooth. It shall be cured for at least 7 days. After the

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surface has partially set, hot bitumen shall be applied in two coats at the rate of 1.7 kg / sq.m per coat and dry sand spread over it.

### 5.5.10 Sheeting Work in Roof and Siding

#### Scope

This specification covers the requirements in respect of materials, workmanship and quality for sheeting work in Roof and Siding of Buildings.

#### Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

- IS : 277 Galvanised steel sheets.
- IS : 730 Hook bolts for corrugated sheet roofing.
- IS : 2096 Asbestos cement flat sheets.
- IS : 5119 Laying and finishing sloped roof coverings.
- IS:1726 Sheet metal rain water pipes.
- IS : 8869 Washers for corrugated sheet roofing.
- IS :12866 Fibre glass reinforced plastic sheets.

#### Materials

Roof and Side sheeting shall generally be of the following types of materials.


- a) Aluminium Sheet (AL)
- b) Galvanised Iron (GI)/Galvanised Steel (GS)
- c) Fibre Glass Reinforced Plastic (FRP)
- d) Colour Coated steel sheets

#### Aluminium Sheet (AL)

Aluminium sheets and accessories shall be of INDAL (Indian Aluminium Company) brand or approved equivalent.

Aluminium roofing and siding shall be of the following types as indicated in the drawings.

- a) Corrugated
- b) Troughed

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Aluminium sheets shall be 0.71 mm and 0.56 mm thick for roof and side sheeting respectively unless otherwise specified.  
Flashing ridge etc. shall be of plain aluminium sheets.

**Galvanized Iron/Steel Sheet (GI/GS)**

Galvanised sheets shall be zinc coated cold rolled sheets, confirming to class 3 of IS 277 and of the following types.

- a) Corrugated
- b) Plain

Galvanised sheets shall be of 1 mm (20G) corrugated sheets for roofing, 0.8 mm (22G) corrugated sheets for side sheeting, flashing etc and 1 mm(20G) plain sheets for ridges, flashing gutters etc unless otherwise specified.

**Fibre-glass reinforced plastic sheets (FRP)**

Fibre glass reinforced plastic sheets shall conform to IS: 12866 and shall be translucent or opaque as shown in drawing. These sheets shall be shatterproof and should not crack, chip or rot.

The sheets shall have uniform thickness, translucency (if specified) and strength. The sheets shall be of approved manufacture and shall match the roofing profiles.

Wherever necessary and as shown in the drawing, caulking shall be of non-hardening and non-staining type.

**Colour Coated Sheets**

**- Permanent colour coated sandwiched insulated metal cladding system**

Troughed zinc - aluminium alloy coated (both sides) MS sheet having 0.6 mm minimum thickness (or high tensile steel sheet of 0.5 mm minimum thickness) shall be used on external face (outer face) of cladding system. Weight of coating shall not be less than 150 gm /sq.m. The outer side (exposed face) shall be permanently colour coated with Polyfluro Vinyl Coating (PVF2) of Dry Film Thickness (DFT) 20 microns (min) over primer. Inner side of external sheet shall be provided with suitable pre-coating of minimum 7 microns.

Galvanized MS sheets of minimum 0.6 mm thickness shall be used as inner liner (internal face) of cladding system. The exposed face shall be permanently colour coated with silicon modified polyester paint of DFT 20 microns (min) over primer.


Inner face of external sheet shall be provided with suitable pre-coating of minimum 7 microns. The rate of galvanization shall not be less than 150 gm /sq .m.

The permanent colour coated sheet shall meet the general requirements of IS : 14246 and shall conform to class 3 for the durability.

Inner sheet shall fixed directly to side runners and Z spacers made of at least 2 mm thick galvanized steel sheet of grade 375 as per IS : 277. Inner sheet shall be fixed at the rate not more than 1.50 m center to center to hold the insulation and external sheeting.

The insulation shall be of bonded mineral wool of minimum thickness 50 mm conforming to IS : 8183, having a density of 32 kg / cu.m for glass wool & 48 kg /cu.m for rock wool.

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- **Permanent colour coated (non-insulated) metal cladding system**

Troughed zinc aluminium alloy coated not less than 150 gm/sq.m M.S sheets having 0.6 mm minimum thickness (or High tensile steel sheet of 0.5 mm minimum thickness) shall be used for the cladding system. The outer side (exposed face) shall be permanently colour coated with PVF2 paint of minimum DFT 20 microns over primer and the inner side (internal face) shall be coated with same paint of minimum DFT 12 microns over primer. These shall be fixed directly to runners. The sheets shall meet the general requirement of IS : 14246 and shall conform to class 3 for the durability.

**General**

The Contractor shall also supply all necessary, special fittings, fasteners, flashings, caulking etc. required for installation of the sheets in strict accordance with manufacturer's instructions.

Roof & siding sheets shall be capable of withstanding 200 kg/sq.m wind loads. Wind tie of 40 mm x 6 mm GI flat shall be fixed at the two caves end of the roof slopes. Fixing shall be done with the same bolts which secure sheets to the purlins. Slot holes shall be cut in the wind ties to allow for temperature variations.

**Installation**

**Aluminium Sheets**

Aluminium sheets shall be fixed with aluminium fasteners along with aluminium curved/flat washers with bituminous felt, neoprene or rubber washers. Generally manufacturer recommendations shall be followed.


**Galvanised Sheets**

Galvanised sheets shall be fixed with minimum 150 mm and 100 mm end laps for roof and side sheets respectively, unless higher laps are specified by the manufacturer or in the drawings. Side laps shall be as per manufacturer's recommendations. Unless otherwise specified, 10 mm and 8 mm dia GI Hook/J Bolts shall be used for roof and side sheets respectively. 6 mm dia GI seam bolt and nut with GI round washer/limpet washer shall be used for stitching of roof sheets/fixtures and GI round washer/diamond washer for side sheets. There shall be at least three hook bolts at the ridges of corrugations in each sheet in every purlin and their spacing shall not exceed 300 mm. Seam bolts shall be placed zigzag on overlapping corrugations, with spacing not exceeding 600 mm in each staggered row. Ridge pieces shall be fabricated from 600 wide (girth) sheets with a radius of curvature of 50 mm unless specified. For fixing requirements not specified here, manufacturer's recommendations shall be adopted.

**Colour Coated Sheets**

Installation procedure and fixing details shall be generally in line with that for GI sheets. The sheets shall be fixed with J or L polymer coated bolts, polymer caps, seal washer and thrust washer. Spacing of bolts etc. shall be identical to GI sheets.

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**Acceptance Criteria**

The installation shall present a neat appearance and shall be checked for water-tightness. The following shall be checked.

- Side and end laps.
- Absence of holes or damages in sheet.
- Spacing of bolts.
- Provision of double washers.
- Proper installation of flashings, wind ties etc.

**5.5.11 Floor and Floor Finishes**


**Scope**

This specification covers requirements in respect of material, workmanship and quality for soling, concrete floor and floor finishes work.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest additions as published by Bureau of Indian Standards and all other such as may be directed published by them during currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed here under:

- |         |  |
|---------|--|
| IS:777  | Specification for glazed earthenware wall tiles.                       |
| IS:2114 | Code of practice for laying in situ terrazo floor finish               |
| IS:2571 | Codes of Practice for laying in-situ concrete flooring                 |
| IS:3461 | Specification for PVC Asbestos floor tiles.                            |
| IS:3462 | Specification for unbacked flexible PVC flooring.                      |
| IS:4457 | Ceramic unglazed vitreous acid-resistant tiles                         |
| IS:5318 | Code of practice for laying PVC flooring.                              |
| IS:5491 | Code of practice for laying in-situ granolithic concrete floor topping |

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### Boulder Soling

The boulders for soling shall be granite, basalt or similar hard stone approved by the Owner/Owner's representative and generally shall be 230 mm thick. The sub grade shall be dressed to correct level and shall be rammed or rolled to proper consolidation before laying the soling. Stones shall be placed close to each other. The specified thickness shall be made up in one or more layers depending on thickness. The voids between the stones shall be hard packed first with smaller pieces and hammered into place so as to completely fill up the void along with murum as binding material and the layer is watered and is compacted by roller/mechanical compactor. In case of building enclosing heavy machinery like Gas turbine/Steam turbine, the compaction shall be by roller of 8/10 MT capacity.

### Cement Concrete Flooring

#### Materials

Requirements given in Section 5.5.5 shall be applicable.

#### Workmanship

The workmanship shall generally conform to the specification for Plain & Reinforced concrete (Section 5.5.5) and also to IS:2571. For ground floor slab or paving in open area, where the slab has to be laid over a consolidated ground, soling, a kraft paper shall be spread over the area and kept moist before concreting.

The floor shall be laid in alternate panels, of size not exceeding 4 m to reduce risk of cracking, intermediate panels being filled in after two or three days. For paving in open area, contraction joint and expansion joints shall be provided as per IS specification. The expansion joints shall be filled with bitumen impregnated boards 25 mm thick of approved manufacturer and top 25 mm shall be covered with approved mastic sealing compound.

### Floor Finishes

#### Indian Patent Stone (IPS) with ironite topping

It shall consist of a under bed and a topping laid on an already laid and matured concrete base.


#### - Thickness

The total thickness of finish shall be 40 mm of which the topping shall be 12 mm. While the topping shall be uniform thickness the under bed may vary in thickness to provide necessary slopes.

#### - Mix

For underbed, it shall be 1:2:4 mix using 10 mm down graded stone chips.

For toppings of heavy duty, the proportion of metallic hardener shall be strictly as specified by the manufacturer. In absence of such direction, one (1) part of metallic hardener shall be mixed dry with 4 parts of cement by volume. To this mixture, 6 mm nominal size stone chips shall be added in portion of 1:3 (mixture of hardener & cement : stone chips) by volume. Minimum quantity of water to be added to make it workable.

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- **Laying**

The topping including the underbed shall be laid in alternate bays or in chequered board pattern. No panel shall be cast in contact with another already laid till the contraction of latter has already been taken place.

The maximum area of each panel shall be 3 sq.m of which no side shall be more than 2 m long.

A cement grout shall be applied and worked into the surface to receive the finish, the under bed then laid, compacted and levelled to proper grade with a screed or float. The topping shall be applied evenly on the underbed while it is not fully set, but firm enough and rolled and pressed to get full bond. The topping shall be troweled to a dense finish to the satisfaction of the Owner/Owner's representative. All trowel marks shall be mopped out with a cloth to give a clean smooth surface.

- **Curing**

After the surface is sufficiently set, the finished floor shall be kept moist for 7 days for curing.

**Indian Patent Stone (IPS) with non-metallic surface hardener finish**

It shall consist of an underbed and a topping on which the hardener shall be laid.

- **Thickness**

The total thickness of finish shall be 40 mm of which the topping shall be 12 mm including the hardener finish.

- **Mix**

Mix for underbed and topping shall be same as for IPS flooring.

- **Hardener**

Hardener shall be non-metallic abrasion resistant surface hardener NITOFLOL HARDTOP or equivalent.


- **Laying**

The topping and underbed shall be laid as for IPS flooring. While the topping is still green, the hardener shall be applied by dry shake-on system. Cleaning of surface, surface preparation, curing and trowel finish shall be as per manufacturer's specifications and recommendation. The surface hardener application rate shall be as follows:

Heavy duty	:	7 kg/m <sup>2</sup>
Medium duty	:	5 kg/m <sup>2</sup>
Light duty	:	3 kg/m <sup>2</sup>

**Precast Terrazo Tile Finish**

It shall consist of manufactured terrazo tiles and an underbed.

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- **Thickness**

The total thickness of finish including underbed shall be minimum 40 mm for floors and 30 mm for skirting. The skirting shall project 6 mm out from the adjacent wall finish. The necessary cutting into the surface receiving tile finish shall also be done.

- **Tiles**

The tiles shall be hydraulically pressed under strict quality control in a shop. The size of tiles shall be 250 x 250 x 20 mm unless otherwise specified. The topping of tiles shall not be less than 10 mm. Maximum tolerance allowance in length & breadth shall be  $\pm 1$  mm and the thickness  $\pm 3$  mm. All angles of tiles shall be right angles, all arises sharp and true, colour and texture of wearing face uniform throughout, and face shall be plane, free from pin holes and other blemishes.

The topping of tiles shall be composed of cement, (grey or white or mixture of two) colour pigment, marble dust and marble chips (chips size 3 to 20 mm) in such a proportion so as to produce the desired colour, texture & pattern approved by the Owner/Owner's representative.

The backings shall be composed of 1 part of ordinary grey cement, 1 1/2 part of sand and 3 parts of 6 mm down graded stone chips mixed with water. First grinding shall be given to the tiles at the shop before delivery. Tiles shall be packed properly to prevent damage during transit and storage. The tiles must be stored carefully to prevent staining of damp, rust, oil and grease or other chemicals.

- **Underbed**

The underbed for floor shall consist of a mix of 1 part cement, 1 1/2 parts coarse sand and 3 parts machine crushed 10 mm down stone chips by volume. For skirting, the mix shall consist of 1 part cement and 3 parts coarse sand. Only sufficient water to be added to give workable consistency.

- **Laying**


The underbed mortar shall be evenly spread and brought to proper grade and consolidated. The surface shall be roughened for better bond. Before the underbed has time to set and while it is still fairly moist but firm, cement shall be hand dusted over it or a cement slurry applied and tiles shall immediately be placed upon and firmly pressed by wooden mallet onto the underbed until it achieves the desired level. The tiles shall be kept soaked for about 10 minutes just before laying. The joints between tiles shall be also as possible and not more than 1.5 mm wide.

When tiles are required to be cut to match the dimensions, these shall be sawn and edges rubbed smooth. The location of cut tiles shall be planned in advance and approval of the Owner/Owner's representative taken.

The floor tiles shall atleast enter 12 mm under the skirting tiles.

After fixing, the floor shall be kept moist and allowed to mature undisturbed for 14 days.

Aluminium or glass dividing strips shall be used for forming the panels.

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- **Grinding and Polishing**

After sufficient curing, the surface shall be ground with fine grit blocks. It shall again be cleared with water, the slurry (mixture of cement & pigment) applied again to fill up any pinholes might have appeared and allowed to be cured again for five days. The surface is ground again with very fine grit blocks to get smooth surface without any pinhole. The grinding shall be done by a suitable machine. Where grinding machine cannot be used, hand grinding may be allowed. The choice of grit blocks at different stages of polishing shall be as per manufacturer's recommendations.

The surface shall be cleaned with water, dried and covered with oil free clean saw dust if directed by the Owner/Owner's representative. The final polishing shall be postponed till before handing over if so desired by the Owner/Owner's representative.

Just before handing over, the surface shall be dusted with oxalic acid at the rate of 0.33 gm per sq.m, water sprinkled on to it and finished by buffing with felt or hessian bobs. The floor shall be cleaned with soft moist rag and dried. If desired by the Owner/Owner's representative, wax polish shall be applied. However, all excess wax polish to be wiped off and surface to be left glossy but not slippery.

**Acid Resistant Tile Finish**

This shall include all varieties of special tiles used for specific chemical/acid resistance function and an underbed over already laid concrete or masonry.

- **Thickness**

The total thickness of finish shall be 50 mm of which the tile shall be 25 mm, acid proof mortar 6 mm, bitumen 3 mm and cement mortar underbed 15 mm.

- **Tiles**

The tiles shall be of best approved manufacture, conforming to IS:4457 and resistant to the chemical likely to come in contact. The tiles shall have straight edges, uniform thickness, plain surface, uniform non-fading colour and textures. The water absorption after 24 hours of soaking shall not be more than 2% by weight. The compressive strength of tiles shall not be less than 700 kg/cm<sup>2</sup>. The surface shall be abrasion resistant and durable.


- **Under bed**

The underbed shall be laid in three layers. The first layer shall be composed for 1 part cement and 3 parts river sand with just enough water to make the mix workable. This layer shall be trovelled level and curved with water for atleast 3 days prior to application of the second layer. The second layer consist of 3 mm thick hot blown bitumen conforming to IS:702 of grade 85/25 and shall be applied in three coats with brush or spray. The third layer of acid proof mortar as specified by manufacturer shall be applied. The acid proof mortar shall have chemical resistant properties equal to that of the floor tiles.

- **Laying**

The tiles shall be embedded in the acid proof mortar and the gap between the tiles shall be grouted to the full depth of tile. The setting and fixing shall be strictly as per the manufacturer's specification and shall be approved by the Owner/Owner's representative.

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- **Curing**

The joints in the floor shall be cured with the solution of 25% proof hydrochloric acid or as specified by the manufacturer.

**In-Situ Terrazzo Finish**

It shall consist of an underbed and a topping laid over an already laid and matured concrete base.

- **Thickness**

Unless otherwise specified the total thickness of the finish shall be minimum 40 mm for horizontal and 25 mm for vertical surface of which the topping shall be not less than 15 mm. While the topping shall be of uniform thickness the underbed may vary in thickness to provide necessary slopes. The vertical surface shall project out 6 mm from the adjacent plaster or other finish. Necessary cutting into the surface receiving the finish shall be done to accommodate the specified thickness. All junctions of vertical with horizontal shall be rounded neatly to uniform radius of 25 mm.

- **Underbed**

The underbed for floors and similar horizontal surfaces shall consist of a mix of 1 part cement, 1-1/2 parts sand and 3 parts stone chips by volume or cement sand mixture 1:3. For vertical surfaces the mix shall consist of 1 part cement to 3 parts sand by volume. The sand shall be coarse. The stone chips shall be 10 mm down well graded. Only sufficient water to be added to give a workable consistency. Stone chips are machine crushed blue granite metal.

- **Topping**

The mix of the topping shall be composed of cement, colour pigment, marble dust and marble chips. Proportions of the ingredients shall be such as to produce the terrazzo of colour, texture and pattern approved by the Owner/Owner's representative. The cement shall be white or grey or a mixture of the two to which pigment shall be added to achieve the desired colour. To 3 parts of this mixture, 1 part marble powder by volume shall be added and thoroughly mixed dry. To 1 part of this mix 1 to 1-1/2 parts of marble chips by volume shall be added and thoroughly mixed dry again.

The pigment must be stable and nonfading. It must be very finely ground. The marble powder shall be from white marble and shall be finer than I.S. Sieve No. 30. The size of marble chips may be between 3 mm to 10 mm.

Sufficient quantity to cover all visible area shall be prepared in one lot to ensure uniform colour. Water to make it just workable shall be added to a quantity that can be used up immediately before it starts to set.


- **Laying**

The underbed shall be laid in panels. The panels shall not be more than 5 sq.m in area of which no side shall be more than 2.5 m long. For exposed locations the maximum area of a panel shall be 2.0 sq.m.

The panel shall be laid in alternate bays or chequered board pattern. No panel shall be cast in contact with another already laid until the latter has contracted to the full extent.

Dividing strips made of aluminium or glass shall be used for forming the panels. The strips shall exactly match the total depth of underbed plus topping. These strips shall be left in place.

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After laying, the underbed shall be levelled compacted and brought to proper grade with a screed or float. The topping shall be laid after about 24 hours while the underbed is still somewhat 'green' but firm enough to receive the topping. Slurry of the mixture of cement and pigment already made shall be spread evenly and brushed in just before laying the topping. The topping shall be rolled for horizontal areas and thrown and pressed for vertical areas to extract all superfluous cement and water and to achieve a compact dense mass fully bonded with the underbed. The surface of the topping shall be troweled over, pressed and brought to a smooth dense surface showing a minimum 75% area covered by marble chips in an even pattern of distribution.

- **Curing**

The surface shall be left for curing for about 12 to 18 hours and then cured by allowing water to stand on the surface or by covering with wet sack for four days.

- **Grinding and Polishing**

When the surface has sufficiently hardened it shall be watered and ground evenly with rapid cutting coarse grade (no.60) grit blocks, till the marble chips are exposed and the surface is smooth. Then the surface shall be thoroughly washed and cleaned. A grout with already prepared mixture of cement and pigment shall be applied to fill up all pinholes. This surface shall be cured for seven (7) days by keeping it moist and then ground with the fine grit blocks (no. 120). It shall again be cleared with water, the slurry applied again to fill up any pinholes that might have appeared and allowed to be cured again for five (5) days. Finally the surface is ground again third time with very fine grit blocks (no. 320) to get smooth surface without any pin hole. The grinding shall be done by a suitable machine. Where grinding machine cannot be used hand grinding may be allowed when the first rubbing shall be with carborandum stone of coarse grade (no.60), second rubbing with medium grade (no.120).

The surface shall be cleaned with water, dried and covered with oil free clean sawdust if directed by the Owner/Owner's representative. The final polishing shall be postponed till before handing over if desired by the Owner/Owner's representative.

Just before handing over the surface shall be dusted with oxalic acid at the rate of 0.33 gm per sq.m, water sprinkled on to it and finished by buffing with felt or hessian bobs. The floor shall be cleaned with soft moist rag and dried. If desired by the Owner/Owner's representative, wax polish shall be applied. However, all excess wax polish to be wiped off and the surface to be left glossy but not slippery. The choice of grit blocks at different stages of polishing shall be as per manufacturer's recommendations.

**Carborandum Tile Finish**

It shall consist of manufactured carborandum tile and an underbed.

- **Thickness**


The total average thickness including underbed shall be minimum 40 mm for floors, and 30 mm for skirting unless otherwise specified.

- **Tiles**

The tiles shall be heavy duty carborandum tile 'STILAN or equivalent', machine made under quality control in a shop. The tiles shall be pressed hydraulically to a minimum of 140 kg/cm<sup>2</sup>.

Each tile shall bear on its back, permanent and legible trade mark of the manufacturer. All angles of the tiles shall be right angles, all edges sharp and true, colour and texture of the wearing face uniform throughout. Maximum tolerance/allowance for length and breadth shall be ± 1 mm and the

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thickness + 3 mm along the wearing surface of the tile and the wearing surface shall be plane and free from pin-holes and other blemishes.

The tiles shall be composed of a backing and topping. The topping shall be of uniform thickness not less than 6 mm. The total thickness including the topping shall be as specified but not less than 20 mm in any case.

The backing shall be composed of 1 part ordinary grey cement, 2 parts and sand 4 parts of stone chips by volume and mixed with water.

The topping shall be carborandum grit (passing 1.18 mm mesh but retained on 0.6 mm mesh) and shall be sprinkled on the surface at the rate of 1.35 kg/m<sup>2</sup> and worked into the surface, to achieve a smooth and uniform surface.

The tile shall be cured at the shop for at least 14 days before delivery to the site. Tiles shall be packed properly to prevent damage during transit and storage. The tiles must be stored carefully to prevent staining by damp, rust, oil and grease, or other chemicals. Tiles made in each batch shall be kept and used separately so that the colour of each area of the floor may remain uniform.

The manufacturer shall supply along with the tiles the grout mix containing cement and pigment in exact proportions as used in topping of the tiles. The containers of the grout mix shall be suitably marked to relate it to the particular type and batch of tiles.

- **Underbed**

The underbed for floors and similar horizontal surfaces shall be 1 part cement, 1.5 parts coarse sand and 3 parts stone aggregate by volume mixed with sufficient water to form a stiff workable mass. For skirting and dado and all vertical surfaces it shall be about 10 mm thick and composed of 1 part cement and 3 parts coarse sand by volume.


- **Laying**

The underbed mortar shall be evenly spread and brought to proper grade and consolidated to a smooth surface. The face shall be roughened for better bond. Before the underbed has time to set and while it is still fairly moist but firm, cement shall be hand-dusted over it or a cement slurry applied and the tiles shall be immediately placed upon and firmly pressed by wooden mallet onto the underbed until it achieves the desired level. The tiles shall be kept soaked for about 10 minutes just before laying. The joints between tiles shall be as close as possible and not more than 1.5 mm wide.

Special care shall be taken to check the level of the surface and the lines of the joints frequently so that they are perfect.

When tiles are required to be cut to match dimension. These shall be sawn and the edges rubbed smooth. The location of cut tiles shall be planned in advance and approval of the Owner/Owner's representative taken.

At the junction of horizontal surface with vertical surface, the tiles on the former shall enter at least 12 mm under the latter.

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**PVC or Vinyl Asbestos Tile/Sheet Finish**

This shall include various types of tiles or sheets manufactured from PVC, set with a sticker on concrete or masonry or particle base. An underbed may be required to secure desirable surface and grade.

- **Thickness**

The thickness of the tiles/sheets shall be 2 mm for light duty and 3.02 mm for heavy-duty applications. The total average thickness including the underbed shall be 40 mm.

- **Tiles**

Unless otherwise specified, the tiles/sheets shall conform to the requirements of IS:3461 & IS:3462 and shall be of approved dimensions. The tolerance in dimensions shall be ± 1.5 mm.

The face of the tiles shall be free from porosity, blisters, cracks, embedded foreign matters or other physical defects which affect appearance or serviceability. All edges shall be cut true and square.

The colour shall be non-fading and uniform in appearance insoluble in water and resistant to alkalies, cleaning agents and usual floor polishes.

Each tile shall be marked on the back legibly and indelibly with manufacturer's trade mark, the thickness, sizes, batch number and date of manufacture.

Tiles/sheets shall be delivered securely packed and stored in a clean, dry, well ventilated place at a temperature near about to that the tiles/sheets shall be called upon to stand ultimately.

Adhesive to be used for sticking the tiles or sheets shall be neoprene based rubber adhesive of approved make and approved by the manufacturer of the tile. The adhesive shall have a short drying time and long life in addition to toughness.

- **Underbed**

The underbed where required to make-up the specified thickness or to give the required grade or to get the right type of surface shall be composed of 1 part cement : 2 parts of coarse sand : 4 parts stone aggregate 10 mm down size, mixed with just sufficient water to make it workable.

- **Laying**


The tiles or sheets shall be kept in the room to be tiled for at least 24 hours to bring them to the same temperature as the room. For air conditioned space, the air-conditioning shall be completed before tiling is taken-up.

The surface to receive this finish shall be firm, even textured, but not too smooth, without undulations and other deficiencies. If an underbed is laid, the same shall be cured for at least 7 days by keeping it moist and then fully dried.

The surface shall be thoroughly cleaned. All loose dust particles shall be removed. Oil and grease, if any, shall be completely cleaned by use of detergent.

The adhesive shall be applied to fully dry surface in desired thickness uniformly. The adhesive shall also be applied to the backs and edges of the tiles or sheets and allowed to surface dry. The tiles and sheets shall be placed neatly on the surface exactly to the approved pattern and set with a suitable tool. If the edges tend to curl up, weights shall be used to keep the edges down. Special

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care shall be taken to avoid formation of air pockets under the tiles or sheets. The joints shall be very fine. Any adhesive squeezed out through the joints shall be removed immediately.

- **Finishing**

If any adhesive mark is there on the surface, a soft cloth soaked in solvent shall be used to wipe it off. The surface shall be cleaned with soft water and soap, dried and polished with an approved type of polish just before handing over.

- **Epoxy Floor Coating**

Epoxy floor coating shall consist of a solvent based, two pack system with epoxy resins and amine curing agents, chosen to withstand high degrees of chemical and abrasive action.

- **Thickness**

Thickness of the epoxy coating including screeding shall be minimum 3 mm. Total thickness of finish including underbed shall be 40 mm when applied on floors of buildings. In pits and dyke areas, no underbed is required to be provided.

- **Materials**

The screed shall be solvent free combination of epoxy resin, modified amine hardeners filled with specially graded and selected chemically inert aggregates of high strength. The system shall include an epoxy resin primer and screed which are both supplied in pre-weighed units ready for on-site mixing and application.

An epoxy resin sealing coat of specified thickness shall form the topping coat.

- **Underbed**

Underbed shall be similar to that PVC floor finish.

- **Laying**


The surface shall be sound, clean and dry in order to achieve maximum adhesion with the primer coating.

The primer shall be applied by brush and shall be allowed to become tacky. The screed shall be prepared as per manufacturers specification and laid in specified thickness evenly over the base floor by trowel. The finished, cured screed shall have a slightly granular texture of uniform brown.

The epoxy resin topping shall be applied at least 24 hours after the laying of the screed. This topping shall be applied by brush or sprayed to a specified thickness in two coats with 3-5 hours interval between them. Care shall be taken to finish the topping perfectly smooth and devoid of any bubbles and unevenness. The newly laid floor shall be protected from dust or moisture and allowed to be used only after a minimum lapse of 48 hours.

**Ceramic Floor Tile/Glazed Wall Tile Finish**

This finish shall be composed of glazed earthen ware tiles with an underbed laid over a concrete or masonry base.

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- **Thickness**

The total thickness shall be between 20 mm and 25 mm including the underbed.

The tile finish on vertical surface shall project out 6 mm uniformly from the adjacent plaster or other wall finishes. The necessary cutting into the surface receiving the finish, to accommodate the specified thickness shall be done.

- **Tiles**

The glazed tiles shall be of earthenware, covered with glaze, white or coloured, plain or with designs, of 100 mm x 100 mm nominal sizes and 5 mm thick, unless otherwise specified. Ceramic floor tiles shall be of matt finish, white or coloured, plain or with designs of 150 mm x 150 mm nominal size and 6 mm thick, unless otherwise specified. The tolerance shall be  $\pm 1.5$  mm for length and breadth and  $\pm 0.5$  mm for thickness.

Specials like internal and external angles, beads, coves, cornices, corner pieces etc. shall match. The top surface of the tiles shall be glazed with a gloss or matt unfading stable finish as desired by the Owner/Owner's representative. The tiles shall be flat and true to shape. The colour shall be uniform and fractured section shall be fine grained in textures, dense homogenous. The tiles shall be strong and free from flaws like cracks, chips, craze, specks, crawlings etc. and other imperfections. The edges and the underside of the tiles shall be completely free from glaze and the underside shall have ribs or indentations for better anchorage with the fixing mortar. The coloured tiles, when supplied, shall preferably come from one batch to avoid difference in colour.

- **Underbed**

The mix for the underbed shall consist of 1 part cement and 3 parts coarse sand by weight mixed with sufficient water or any other mix if specified.

- **Laying**

Procedure for laying shall be same as that for precast terrazo tiles.

- **Finishing**

The joints shall be cleaned and flush pointed with white cement and cured for seven (7) days by keeping it wet. The surface shall be cleaned with soap or suitable detergent, washed fully and wiped with soft cloth to prevent scratching before handing over.

**5.5.12 Doors, Windows, Louvres, Rolling Shutters & Glazing**


**Scope**

This specification covers the requirements in respect of materials, workmanship and quality for doors, windows louvres, Rolling Shutters and glazing work.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

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**Metal Doors & Windows**

- IS:733 Wrought aluminium and aluminium alloy bars, rods and sections (for general engineering purposes)
- IS:1038 Steel doors, windows and ventilators
- IS:1361 Steel windows for industrial buildings
- IS:1948 Aluminium doors, windows and ventilators
- IS:1949 Aluminium windows for industrial buildings.
- IS:4351 Steel door frames


**Timber Doors**

- IS:4021 Timber door, window and ventilator frames
- IS:1003 Timber paneled and glazed shutters.
- IS:2191 Wooden flush door shutter (cellular and hollow core type)
- IS:2202 Wooden flush door shutters (solid core type)

**Rolling Shutters**

- IS:6248 Metal rolling shutters and rolling grills
- Glazing
- IS:1081 Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators
- IS:2553 Safety Glass - Specifications
- IS:2835 Flat transparent sheet glass
- IS:3548 Code of practice for glazing in buildings
- IS:5437 Figured rolled and wired glass  
Builder's Hardware
- IS:204 Tower bolts
- IS:205 Non-ferrous metal butt hinges
- IS:208 Door handles
- IS:281 Mild steel sliding door bolts for use with padlocks
- IS:363 Hasps and staples
- IS:723 Steel counter sunk head wire nails
- IS:1823 Floor door stoppers

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IS:2209	Mortice locks (vertical type)
IS:2681	Non-ferrous metal sliding door bolts for use with padlocks
IS:3564	Door closers (hydraulically regulated)
IS:3847	Mortice night latches
IS:4992	Door handles for mortice locks (vertical types)
IS:6607	Rebated mortice locks (vertical type)

**Materials & Workmanship**

**Steel doors, Windows, Ventilators Etc.**

**- Door Frames**

Frames shall be rolled or pressed sections from 18 g sheet conforming to IS: 4351. They shall be mortised, reinforced, drilled and tapped for hinges and lock and bolt strikes where necessary, frames shall be reinforced for door closures. Welded construction with mitred corners shall be used. Rubber door silencers shall be furnished for the striking jamb. Loose 'T' masonry anchors shall be provided. Frames shall finish flush with floor and adjustable floor anchors shall be supplied. Frames shall be brought to site with floor ties/ weather bars installed in place.

**- Double Plate Flush Door Shutters**


Door shutters shall be 45 mm thick, completely flush design and shall comprise of two outer sheets of 18 g steel sheets, rigidly connected and reinforced inside with continuous vertical 20 g stiffeners, spot welded in position at no more than 150 mm on centres. Both edges of doors shall be joined and reinforced full height by steel channels placed immediately inside and welded to the door faces. Top and bottom of doors shall be reinforced horizontally by steel channels running full width of door. Doors shall not have more than 2.5 mm clearance at jambs and head, shall have proper bevel on lock stiles and rails to operate without binding, and shall be reinforced at corners to prevent sagging or twisting. Pairs or double doors shall have meeting-stile edges bevelled or rebated.

Doors shall be mortised, reinforced, drilled and tapped in shop for hinges, locks and bolts. They shall also be reinforced for closures, push-plates and other surface hardware where necessary. Any drilling and tapping required for surface hardware shall be done at site. Where necessary, provision shall be made for fixing glazing, vision panels, louvres etc. glazing mouldings shall be of 18 g steel and suitable for fixing 6 mm glass. Louvre blades shall be V or Z shaped and made out of 16 g sheets.

**- Sliding Doors**

Sliding doors shall be double plate construction made out of 18 g steel sheets with adequate stiffness. The Contractor shall specify the weight of the door in his shop drawing and submit the manufacturer's catalogue of the sliding gear he proposes to use. Where shown on drawings, the Contractor shall make provisions for openings in the door for mono-rail beams. Doors shall close positively to exclude rain water from seeping in. Sliding doors shall withstand specified wind loads without buckling or jamming. The door shall slide freely under all ambient conditions.

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- **Steel Windows, Sashes, Ventilators, etc.**

These shall conform in all respects to IS: 1038 and IS:1361. The details as called for in the above codes shall be applicable for coupling mullions, transoms, weather bars, pivot arrangements for ventilators, etc.

All welds shall be dressed flush on all exposed and contact surfaces.

Where composite unit openings are provided the individual window units shall be joined together with requisite transoms and mullions. All windows shall be outside glazed, fixed with putty or metal glazing beads.

All welds at the corner of casement shall be done by flash butt welding process and dressed flush on all exposed and contact surfaces.

**Aluminium Doors, Windows and Frames**

Aluminium sections for fabricating doors, windows, partitions etc., shall be extruded sections conforming to IS:1948 & IS:1949 or as manufactured by Indian Aluminium Company Ltd or approved equivalent. The alloy used shall conform to IS designation HE 9-WP of IS:733.

Extruded sections shall have a minimum 2.5 mm wall thickness. All sections shall be approved by the Owner/Owner's representative before fabrication is taken up. Doors, frames, mullions, transoms etc. shall be anodized in a bath of sulphuric acid to provide a clear coating of minimum

0.06 mm thickness. The anodised materials shall then be sealed by immersing in boiling water for 15 minutes. A protective transparent coating shall be applied to the sections before shipment from the factory.

All work shall be fitted and shop assembled to a first class job, and ready for erection. Shop joints shall be made to hair lines and then welded or braced by such method as will produce a uniform colour throughout the work. Work on the above, other than described, shall be neatly finished with concealed fasteners. Glazing beads shall be snap fit type, without visible screws and shall be of sizes to accommodate 6 mm thick glazing.

**Timber Doors**


All timber shall be best quality well seasoned specified species free from large or loose knots cracks or other defects. Where specified, timber shall be treated with approved wood preservative before starting the joinery work, the Contractor shall have the rough timber approved by the Owner/Owner's representative.

Plywood shall be of commercial quality teak veneer or with decorative surface veneer as specified.

The core for solid core doors shall be of block board or wood particle board. Manufacturer's literature and test certificates shall be submitted for the approval of the Owner/Owner's representative. The Contractor shall give a guarantee that the adhesive used is phenol-formaldehyde confirming to IS:848.

Fixtures for doors, windows, furniture etc. shall be as shown on drawing. These shall be of heavy type, best quality and from approved manufacturer. The Contractor shall have to mention the name of the manufacturer for different types of joinery hardwares, fittings and fixtures. Samples of each type of fittings shall have to be submitted to the Owner/Owner's representative for obtaining approval before bulk supply.

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The work shall be done by skilled carpenters as per details shown on drawing or instructed by the Owner/Owner's representative.

Framing timber and other work shall be close-fitting with proper wood joinery, accurately set to required lines or levels and rigidly secured in place. The surface of frames etc. which will come in contact with masonry after fixing shall be given two coats of approved paint before fixing. Mastic caulking shall be done after fixing external door and window frames. Special care shall be taken to match the grain of timber or plywood which will be subsequently polished. Screwing or nailing will not be permitted to the edge of plywood or chip-board sheets. All exposed plywood edges shall be finished with teakwood timber lipping unless otherwise shown on drawings.

All carpentry work after finishing shall be sand papered smooth. Prime coat paint shall be given after inspection of the Owner/Owner's representative to all surfaces other than those which shall be subsequently polished or covered with laminated plastic sheet.

When shown on drawings decorative ply or laminated plastic sheets shall be bonded under pressure to the surface to be finished. The adhesive used shall be of approved brand and bought to site in sealed containers. The rate of application and the length of time for which the pressure is to be applied shall be as per the manufacturer's instruction. The edge of sheets shall be protected by teakwood timber lipping. However, where available factory made ready for use material of reputed manufacturer shall be used.

All frames shall be square and flat at the time of delivery and shall be checked for dimensions and corner angles. After fixing they shall be on a fine vertical plane. All external door and window frames shall be caulked with mastic.

**PVC Doors & Windows**

PVC doors and windows shall be obtained from reputed manufacturers and shall be SINTEX or approved equivalent quality. The material used shall be unplasticised PVC having superior impact resistance. Density of the material shall be 1.4 grams/cm<sup>3</sup> and tensile stress and bending stress of 480 and 770 kilopascal/cm<sup>2</sup>. The outer section wall thickness shall be min. 1.7 mm.

The section shall be reinforced with steel sections concealed inside a cavity of PVC sections. Corners shall be welded, transom/mullions welded or mechanically joined. Weather sealing shall be by double sealing with elastomeric weather strip, the corners being glued.

Opening for PVC doors/windows shall be 10 mm more than the window/door size.


The doors shall be fixed to the wall by expandable fasteners or by brackets. Manufacturer's recommendation shall be followed for installation.

**Rolling shutter (Hand operated, Mechanical gear operated and Electrically operated).**

Rolling shutters shall be fabricated from 18 gauge steel and machine rolled with 75 mm rolling centres with effective bridge depth of 12 mm lath sections, interlocked with each other and ends locked with malleable cast iron clips to IS:2108 and shall be designed to withstand a wind load of 200 Kg/m<sup>2</sup> without excessive deflection.

The guides shall be either rolled or pressed deep channel sections 75 mm and 25 mm wide fitted with necessary fitting and fixtures.

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The suspension shaft shall be formed from heavy duty tubes conforming to IS:1161 and of sufficient diameter so as to resist deflection due to weight of the rolling shutter. The deflection shall not exceed 5 mm/ metre width. The shaft shall be provided with CI pulleys and helical springs for counter balancing the weight of the shutter adequately.

The springs shall be approved high tensile flat springs conforming to Grade 2 of IS:4454. These shall be fitted inside the fabricated housing of either ends which counter-balance the shutter curtain.

The ball bearings shall be double row self-aligning ball bearings fitted inside C.I. housing fixed on side brackets holding the suspension shaft at either end. The roller assembly shall be designed so as to be capable of producing sufficient torque to ensure easy operation of the rolling shutter in any position. The spring tension shall be adjustable by means of suitable adjustments holes drilled on the rims of the pulley.

The hood cover shall be made of 20 gauge galvanized sheets with necessary stiffeners and framework to prevent sag. The bottom lock plate shall be made of 5 mm thick M.S. plate and 95 mm wide reinforced with angle/T iron of suitable section with 6 mm dia M.S. rivets interlocked with last stride of curtain.

The locking arrangement shall consist of sliding bolts at both ends of the bottom plate fitted to engage with suitable receiving pockets at the bottom of guide channels.


Unless otherwise specified, for overall area of rolling, shutters up to 9 sq.m pull and push type hand-operated shutters shall be used; for area between 9 and 12 sq.m pull and push type shutters shall be provided with ball bearings; for area larger than 12 sq.m mechanical gear type or electrically operated shutters shall be supplied.

### Glazing

Glass for glazing shall be of the following types:

- 4 mm thick transparent sheet glass conforming to IS:2835 generally used for openable shutters of windows.
- 6 mm thick wired glass conforming to IS:5437 generally used for fixed shutters of windows.
- 6.3 mm thick laminated safety glass conforming to IS:2553 generally used for fixed glazed partitions.
- 6 mm thick transparent sheet glass used for aluminium glazed doors.

All glass shall be cut according to the sizes required as per drawings. Glazing of metal doors, windows and ventilations shall conform to IS:1081 either with putty or metal clips. The Contractor shall thoroughly clean all glass and replace all putty or glass damaged during the work.

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**Double Glazing**

Shall be as per approved manufacturer's specifications and relevant IS codes.

**Storage and Handling**

All metal doors, windows etc. shall be packed and crated properly before despatch and shall be stored under cover in a way to prevent damage or distortion. Special care shall be taken to prevent staining of aluminium products by rust or mortar etc. Glass shall be brought to site in manufacturer's original packing.

**Assembly and Erection**

The Contractor shall assemble and install all doors, windows, louvers, etc. including transoms mullions for composite units in respective places keeping proper lines and levels, and in approved workman like manner, to give trouble free and leak proof installations. The installations shall be done according to the instructions of the manufacturer and/or as approved by the Owner/Owner's representative. If required by the Owner/Owner's representative, the installation shall have to be carried out under the supervision of the manufacturer's staff.

After installation of steel doors, windows etc. all abrasions to shop-coat of paint shall be retouched and made good with the same quality of paint in shop coat. All coupling mullions, transoms, frames etc. in contact with adjacent steel and other members shall be well bedded in mastic. Door shutters, partitions, hardware fixtures shall be fixed only after major equipments have been installed in rooms.

**Hardware and Fixtures**

Hardware and fixtures shall be best quality from the approved manufacturers and shall conform to the relevant IS specification and able to withstand repeated use. The Contractor has to provide the required number / size of fixtures for trouble free operation and adequate strength. Door closers shall be suitable for shutter weight and shall be guaranteed against manufacturing defect for one year and any defect found within this period shall be rectified or the door closer replaced without extra cost to the Owner/Owner's representative.


The Contractor shall submit samples of each type of hardware to the Owner/Owner's representative and the approved samples shall be retained by the Owner/Owner's representative for comparison with bulk supply.

**5.5.13 Painting, Colour Washing Etc.**

**Scope**

This specification covers the requirements in respect of materials, workmanship and quality for finishing works, such as white washing, colour washing, distemping and painting to masonry, concrete, timber and metal surfaces of doors, windows, rolling shutters etc. Separate specification shall be referred for painting of structural steel work.

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**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Indian Standards Institution and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

**White washing, colour washing and distempering**

- IS:427 Distemper, dry colour as required
- IS:428 Distemper, oil emulsion, colour as required
- IS:6278 Code of practice for white washing and colour washing


**Painting**

- IS:5 Colours for ready mixed paints and enamels
- IS:102 Ready mixed paint, brushing, red lead, non-setting, priming
- IS:123 Ready mixed paint, brushing, finishing, semigloss, for general purposes
- IS:1477 Code of practice for painting of ferrous metals in buildings
- IS:2074 Ready mixed paint, air drying, red oxide-zinc chrome, priming
- IS:2338 Code of practice for finishing of wood and wood based materials.
- IS:2339 Aluminium paint for general purposes in dual container
- IS:2395 Code of practice for painting concrete, masonry and plaster surface
- IS:2932 Enamel, synthetic, exterior, a) undercoating, b) finishing.
- IS:2933 Enamel, exterior, a) under coating, b) finishing.
- IS:5410 Specification for cement paint, colour as required
- IS:5411 Specification for plastic emulsion paint

**Materials**

**Distemper**

Dry Distemper shall be made from suitable pigments, extenders lime proof tinters, water soluble binders confirming to IS:427. Oil bound washable distemper shall be of oil emulsion type containing suitable preservatives confirming to IS:428.

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**Gum and blue pigment**

Gum and blue pigment for white wash shall be of best quality and of approved make.

**Water Proof Cement Paint**

Water proof cement paint shall be made from best quality white cement and lime resistant colours with accelerators, water proofing agents and fungicides. The paint shall confirm to IS: 5410.

**Paint**

The painting and finishing materials for use in the work shall conform to relevant Indian Standards specifications and shall be best brands of approved make produced for each kind of work. Aluminium paint shall be in two back containers and shall resist weathering.

The acrylic emulsion paint, after it is dried, shall be able to withstand washing with mild soap and water without any deterioration in colour or without showing flaking, blistering or peeling.

**Primer coat**

Unless otherwise specified, the primer coat for concrete, steel and iron work shall be as specified by the manufacturer.

**Weather Shield coating**

Shall be as per approved manufacturer's specifications and relevant IS codes.

**Acrylic Emulsion Paint**

Shall be as per approved manufacturer's specifications and relevant IS codes.

**Textured Paint**

Shall be as per approved manufacturer's specifications and relevant IS codes.

**Acid Resistant Paint**

Shall be as per approved manufacturer's specifications and relevant IS codes.

**Enamel**


Shall be as per approved manufacturer's specifications and relevant IS codes.

**White Washing, Colour Washing and Distempering**

**Mixing**

The slaked lime shall be screened to pass through a sieve of 49 meshes per sq.cm. and dissolved in a tub with sufficient quantity of water and shall be well mixed to give a thin creamy consistency. It shall then be strained through a clean coarse cloth and clean gum dissolved in hot water added to it at the rate of 2 kg for each cubic meter of lime and ultramarine blue added to the mixture in small proportion just sufficient to give a very light bluish tint.

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Colour wash shall be prepared in the same way as for white washing except that necessary amount of colouring matter shall be added to lime wash to obtain the colour specified. No blue shall be added in this case. The entire quantity shall be mixed strictly in accordance with the manufacturer's instructions unless these are varied by the Owner/Owner's representative.

Distemper shall not be mixed in a larger quantity than is actually required for a day's work and hot water shall be used in preparing the mixture.

**Preparation of Surface**

Before white wash is laid on new wall, the surface of wall shall be well cleaned and brushed and all patching must be scraped properly. After cleaning the surface, all holes, cracks and patches shall be made good with approved materials.

Masonry cracks shall be cleaned out and patch filled with mortar similar to the original surface and finished with cement wash. For all internal painting the surface shall be made smooth by application of approved paste fillers before applying primer.

The distemper shall not be applied on damp walls and shall be applied in dry weather. The surface to be distempered shall be thoroughly cleaned of dust, dirt, grease, oil marks, cement marks, loose scales etc. and rubbed with sand paper to give a uniform smooth surface.

**Workmanship**


White wash shall be applied with brush, each coat consisting of vertical stroke from top downwards followed by opposite stroke upwards over the first stroke and horizontal stroke from left to right followed by stroke right to left. Each coat must be allowed to dry before the next coat is applied. On completion, the surface when it becomes dry, shall present a uniform white appearance. When dry, no coat of white wash shall show any patches, haircracks or streaks nor shall it come off when rubbed with hands. White washing shall be done in 3 coats unless otherwise specified. Doors, windows, floors etc. must be protected from white wash splashes. Any splashes and droppings shall be removed and cleaned.

Colour wash shall be applied in the same manner as specified for white wash. During application, the solution shall be stirred continuously and wash shall be applied with care to avoid any cut shade or brush marks on the walls when the work is complete. For all new work, the surface to be colour washed shall first be treated with a priming coat of lime wash. Unless otherwise specified, two coats of white wash shall first be applied before colour wash is applied. The colour wash, whether applied inside or outside of a building shall be of uniform tint and shade.

The workmanship for distemping shall conform to IS:427 and IS:428 unless specified otherwise. Distemping shall be done with proper distemper brushes of approved quality. The finished surface shall be of absolutely uniform shade throughout and free from brush marks. On drying, the distemper shall not come off on touch and shall not crack. Distemper shall be applied in two coats over one coat of priming. The priming coat shall be as specified and the primer shall be in accordance with the recommendation of the manufacturer. Before applying the primer, the plastered surface shall be washed with a solution of 100 gm of zinc sulphate to one litre of water and then allowed to dry. Succeeding coats shall not be applied until the previous coat has been approved by the Owner/Owner's representative. The first coat shall always be of a lighter tint and shall be applied with care. In case the finish is not up to the standards, the entire surface shall be sand-papered and a fresh coat or coats of distemper shall be supplied without any extra cost.

All decorative mouldings, cornices, bands etc. shall be finished according to detailed drawings. All splashes of distemper shall be removed by the Contractor at his own cost.

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The surface to be coated with water proof cement paint shall be washed and brushed down. As soon as the moisture has disappeared, the surface shall be given one coat of paint. Care shall be taken so that the paint does not dry out too rapidly. After four to six hours, water shall be sprinkled over the surface to assist curing and prevent cracking. After the first coat has dried (24 to 48 hours), the second coat shall be applied in a similar manner. The finished surface shall be kept moist by occasional sprinkling with water for seven days after painting.

**Painting**

**Preparation of surface**

The surfaces of iron and steel work to be painted shall be cleaned free of dirt, oil, rust, millscale and be thoroughly dry before painting. Cleaning, degreasing, derusting and descaling wherever necessary shall be carried out as specified in IS:1477 (Part I). All galvanised iron surfaces shall be pre-treated with a compatible primer according to the manufacturer's direction.

The surfaces of wood shall be rubbed down smooth. All nails and screws shall be sunk below the surface and filled with mastic after applying an under coat. Small knots that do not justify cutting and sap streaks shall be covered with minimum two coats of pure shellac coating applied thinly and extended 25 mm beyond the area. All large, loose or resinous knots shall be removed and filled with sound wood. All work shall be done as per IS:2338.

**Application**

Painting of iron and steel work shall generally be carried out as per IS:1477.

The paint manufacturer's specification/instructions shall be followed as far as possible at all times. Particular attention shall be paid to the following:


- a. Proper storage to avoid exposure, as well as extremes of temperature.
- b. Surface preparation prior to painting
- c. Mixing and thinning
- d. Application of paints and the recommended time limit on time intervals between coats.

Painting operations shall not proceed until the Owner/Owner's representative has the opportunity to inspect the condition of prepared surface to be painted. Paint shall be thoroughly mixed and not more than 1/2 kg of recommended thinner per 4.5 kg litres of paint shall be added if thinning is necessary. Exterior paint shall not be performed during the period of inclement weather. Interior painting may proceed during such periods only with the approval of the Owner/Owner's representative. Prior to application of subsequent coat, the Owner/Owner's representative shall be given the opportunity to inspect the prior coat. Should the work be judged by the Owner/Owner's representative be inferior, a supplementary coat shall be applied at no additional cost.

The number of coats including the primer coat shall be applied as specified. Each coat shall be allowed to dry sufficiently before the succeeding coat is applied.

The type of intermediate and finish coat and the number of coats to be applied shall be as specified. Intermediate and finish coats may be oil bound, bituminous, aluminium or other types of paints. The intermediate and finish coats for structural steel work, sheet metal work and cast iron work shall be applied as specified in IS:1477 (Part II).

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**Acceptance Criteria**

- a) All the painted surface shall be uniform and pleasing in appearance.
- b) The colour, texture etc. shall match exactly with those of approved samples.
- c) All stains, splashes and splatters of paints shall be removed from surrounding surface.

**5.5.14 Water Proofing**

**Scope**

This specification covers the requirements in respect of materials, workmanship and quality for water proofing of roofs and underground structures.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

- IS:1322 Bitumen felts for water proofing and damp proofing
- IS:1346 Code of practice for waterproofing of roofs with bitumen felts
- IS:1580 Bituminous compound for water proofing and caulking purposes.
- IS:1609 Code of practice for laying damp-proof course using bitumen felts
- IS:2645 Integrated cement water proofing compounds (1987)
- IS:3067 Code of practice for general design details and preparatory work for damp-proofing and water-proofing of building.
- IS:7193 Specification for glass fibre base coal tar pitch and bitumen felts.


**Materials**

**Bituminous Polymeric membrane for roof water proofing.**

Bituminous Polymeric membrane used for waterproofing of roofs shall be 5 layered membrane consisting of a central core of 90 microns thick High Molecular High Density Polyethelene (HMHDPE) film protected on both sides with polymeric asphaltic mix and further covered on both sides with protective thermofusible HMHDPE film. For precast roofs, the top HMHDPE layer shall be substituted with embossed aluminium foil 75 microns thick. Product to be used for cast-in-situ roof slab shall be MULTIPLAS STANDARD and that for roof with precast slab panels shall be MULTIPLAS ALUMINIUM or approved equivalent.

**Bituminous polymeric membrane for underground damp proofing.**

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The membrane used for waterproofing underground structures shall be 7 layered membrane similar to 5 layered roofing membrane, but reinforced with a non woven polyester mat of minimum 140 g/m<sup>2</sup> for additional mechanical strength and covered with additional layer of polymeric asphalt. Product to be used shall be MULTIPLAS HYPER or approved equivalent.

**Bitumen Felt**

It shall conform to IS:1322.

**Fibre Glass Tissue Reinforced Bitumen Felt**

It shall conform to IS: 7193, consisting of reinforced glass fibre base coated on both sides with bitumen modified with thermo plastic polymers.

**Bonding Materials**

Bonding materials used for applying the polymeric bituminous membrane on surfaces shall be fibre and solvent based, rubber modified bituminous primer of density 0.92 g/cm<sup>3</sup> with viscosity 500 to 10,000 cps. Ordinary bitumen wherever used shall be of blown type conforming to IS:702 or residual bitumen conforming to IS:73 or a mixture thereof.

**Water proofing admixture**

The water proofing admixture shall conform to IS: 2645 and shall be approved by the Owner/Owner's representative.

**Cement**

Cement shall conform to IS 455 or IS:1489.

**Aggregates**

The aggregates shall conform to IS:383. Fine aggregate shall be river sand or pit sand from approved pits. Coarse aggregate shall be stone chips of size not exceeding 6 mm.

**Metal Flashings**

Metal flashings shall be of 18 g or 20 G galvanised iron.

**Workmanship**


**Waterproofing of roof**

- **With polymeric bituminous membrane**

The roof slabs shall be cleaned of all dust, dirt, grit etc. and if rough it shall be made reasonably smooth either by clipping of projections or by applying a thin coat of cement slurry of cement sand and water. The roof surface shall be regraded prior to waterproofing with cement mortar or concrete screed to provide a minimum slope of 1:75 for cast-in-situ roofs and 1:50 for precast roofs. At the places of drain outlets, projecting pipes, parapet walls and expansion joints etc. the surface shall be prepared in indicated in IS : 1346.

Over the hardened and finished surface of roof slab, suitable approved primer such as MULTIPLAS PRIMER or approved equivalent is coated at the rate of 250 g/cm<sup>2</sup>. The waterproofing membrane is unrolled over the coated surface with overlaps of 100 mm and bonded completely to the substrate.

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The overlaps are then sealed by flame. Installation of the waterproofing membrane shall be strictly as per the manufacturer's instructions and supervision.

In case of roofs with parapets, a chase 75 mm deep shall be cut in the parapet masonry at about 150 mm above the roof level and the membrane shall be laid as flashings in widths with a minimum overlap of 100 mm. The lower edge of the flashing shall overlap the membrane laid on the flat portion, and the upper edge of the flashing shall be tucked into the groove made in the parapet. After the flashing has been properly bonded, the chase shall be cleaned and shall be filled up with cement mortar 1 : 4 flush with the face of the wall, and allowed to set by adequate curing.

For gutters, the membrane shall be laid over a primer coat, and finally painted with a coat of hot bitumen at not less than 1.5 Kg/sg.m. The membrane treatment shall be carried down into the outlet pipes to a minimum depth of 100 mm.

After the treatment is over, the surface shall be covered with 20 mm plaster of cement mortar 1:4 reinforced with chicken wire mesh marked off into squares 600 mm wide with expansion joints provided at a distance of 3 metres for cast-in-situ accessible roofs.

**- With hessian based bitumen felts**

The roof slab shall be cleaned of all dust, dirt, grit etc. and if rough it shall be made reasonably smooth either by chipping of projections or by applying a thin coat of cement slurry of cement, sand and water.

The roof surface shall be regraded prior to waterproofing either with cement mortar or lime-surkhi mortar. At the places of drain outlets, projecting pipes, parapet walls and expansion joints etc. the surface shall be prepared as indicated in IS:1346.

The workmanship in general shall conform to IS:1346 unless otherwise specified. Over the hardened and finished surface of the roof slab, a thin layer of approved bitumen primer shall be first brushed over the roof surface and allowed to dry.


The felt shall be first cut to the required lengths and laid out flat on the roof in position at right angles to the direction of run-off gradient and shall be brushed clean of dusting materials. Each length of felt thus laid in position shall be rolled up for a distance of half of its length. Then the bonding material heated to correct temperature shall be poured on to the roof across the full width of the rolled felt as the latter is steadily rolled out and pressed down. Excess bonding material shall be squeezed out at the ends and removed as the laying proceeds. When the first half of the strip of felt has been bonded to the roof, the other half shall be rolled up and then unrolled on to the hot bonding material in the same way.

Minimum overlaps of 100 mm shall be allowed at the end and the sides of strips of felt. All overlaps shall be firmly bonded with hot bitumen. The laying of the second layer of felt shall be so arranged that the joints are staggered with those of the layer beneath it.

In case of roofs with parapets, a chase 75 mm deep shall be cut in the parapet masonry at about 150 mm above the roof level and the felt shall be laid as flashings in widths with a minimum overlap of 100 mm. The lower edge of flashing shall overlap the felt laid on flat portion of the roof and the upper edge of the flashing shall be tucked into the groove made in the parapet. After the flashings have been properly bonded, the chase shall be cleaned and shall be filled up with cement mortar (1:4) flush with the face of the wall and allowed to set by adequate curing.

In case of drain mouths, waterproofing shall be done as specified for the roof excepting that the treatment shall be carried inside the drain pipes overlapping at least 100 mm.

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For gutters, a priming coat shall first be applied. Over this, a specified number of layers of felt shall be laid and bonded together with hot bitumen and finally painted with a coat of hot bitumen at not less than 1.5 kg per sq. metre. The felt layers laid separately in the gutters shall be overlapped with the corresponding layers on the roof proper. The felt treatment shall be carried down into the outlet pipes to a minimum depth of 100 mm.

After the treatment is over, the surface shall be covered by pea-sized gravel or grit at the rate of 0.6 cu.m per 100 sq.m. On flashings and at drain mouths a finish of two coats of approved bituminous primer shall be provided.

- **With fibre glass tissue reinforced bitumen felt**

Water proofing for roofs shall be according to the guide lines in IS:1346. Other requirements shall be the same as those for hessian based bitumen felt.

- **With brick lime concrete and pressed flat tiles**

The exposed surfaces of the roof slab shall be thoroughly cleaned. A layer of brick lime concrete shall be laid over the cleaned surface. Brick lime concrete shall be 1:2:4 by volume using 20 mm down graded brick bats. The slope of the lime concrete layer shall be 1:100 and the minimum thickness shall be 80 mm. The slope of the draining surfaces shall be formed on all the sides as necessary.

Care shall be taken to check the quantity of water. The quantity of water shall be so as to make the concrete just workable. Cement sand mortar 1:3 with 2% mixture of "Accoproof"(or approved equivalent water proofing agent) shall be laid over the underbed to a thickness of 20 mm. Pressed flat tiles are set over the mortar and pointed with cement mortar 1:3 with 2% "Accoproof" (or approved equivalent water proofing agent).

**Damp proofing of underground structures**

- **With polymeric bituminous membrane**

Prior to application of the membrane, the surface shall be coated with MULTIPLAS PRIMER or equivalent applied at the rate of 250 g/m<sup>2</sup>. Application procedure will be similar to roof water proofing, strictly as per manufacturer's instructions and supervision. Membranes shall be fastened with the vertical surfaces for height exceeding 4,5 mtrs. Half brick thick brick work in cm 1 : 4 shall be provided as protection to waterproofing on external side faces.


- **With hessian based bitumen felts**

Damp proofing for underground structures wherever indicated shall be done as per recommendations of IS:1609, for heavy treatment with three layers of felt. The method of laying damp proofing treatment shall be as per IS:1609.

- **With fibre glass tissue reinforced bitumen felt**

It shall be done as per guidelines laid in IS:1609 and those specified for hessian felts. The felt layers shall be fastened to the wall surface wherever the height exceeds 4.5 metres. Half brick wall in CM 1.4 shall be erected as protection to the external face of the water proofing.

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The slopes and surface level shall be such as to allow quick draining of water without leaving any pool anywhere. The finishing course shall be fully secured and shall have an even density. There shall not be any bubble formation or crushed or squeezed insulation or underbed.

The Contractor shall give a guarantee in writing for all works executed under this specification supplemented by a separate and unilateral guarantee from the specialised agency for the waterproofing treatment work. The guarantee shall be for materials and workmanship for five (5) years.

**5.5.15 False Ceiling and False Flooring**

**Scope**

This specification covers the requirements in respect of materials, workmanship and quality for suspension system and ceiling panels required for false ceiling work and false flooring work.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed here under :

- IS:848                 Synthetic resin adhesives for plywood
- IS:1642               Code of practice for fire safety of buildings.
- IS:2095               Gypsum plaster boards
- IS:2441               Code of practice for fixing ceiling coverings.
- IS:3087               Wood particle boards for general purposes.
- IS:3129               Low density particle board.
- IS:4671               Expanded polystyrene for thermal insulation purposes


**Materials**

**Ceiling Panels for False Ceiling**

Ceiling panels shall be of best quality material in thickness and properties specified. The Contractor shall submit test certificate to the Owner/Owner’s representative for approval before bulk supply.

The ceiling panels may be of the following types manufactured by reputed manufacturers

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**- Teakwood particle board**

Teakwood particle board shall conform to IS:3087 (3 layer flat pressed particle board bonded with BWP type phenol Formaldehyde Synthetic resin conforming to IS:848), satisfying the requirements of Class I of IS:1642 and treated with antifungus Chemicals. The bottom (facing the floor) of tiles shall be painted with two coats of acrylic emulsion paint over a coat of primer.

**- Gypsum board**

Gypsum board shall conform to IS:2095 and shall have the following properties

- Thermal conductivity : 0.16 W/mK
- Thermal resistant : 0.06 to 0.09 m<sup>2</sup> K/W
- Fire propagation : Class-1

**- Aluminium panels**

Aluminium panels shall be square edged plain panels, 84 mm wide x 15 mm deep with 25 mm recessed flanges, formed out of 0.5 mm thick aluminium alloy electrically powder coated in standard colours. LUXALON 84C or approved equivalent shall be used.

**Floor Panels for False Flooring**

- Particle board with PVC tiles
- Cement fill metallic panels with antistatic HPL tiles

Floor panels for false flooring shall be of 600x600x32 mm cement fill metallic false flooring panels with 1.2 mm thick antistatic, high abrasion resistance, high pressure laminate tiles on faced on top (Lloyd insulations or approved equivalent) unless otherwise specified. All steel works and stools shall be provided with two coats of polyurethane paint over a coat of approved primer. Each panel shall have PVC beading on all edges. The floor panels shall be of completely removable type. The clearance under the floor shall be as per drawing, The floor panels shall be cut wherever required for providing suitable outlets for cables etc.

The false flooring Panel shall be provided for the area of cable route as per requirement and the other areas shall be covered with PVC antiskid flooring.


**Installation**

The Contractor shall prepare a layout for false ceiling showing the framing and the cut outs for AC/Electrical fixtures and other services and get the same approved before commencement of work.

**Suspension system for false ceiling boards**

Suspension system shall consist of the grid supporting the ceiling panels, intermediate runner supports for the grid if any and hangers, wall angles etc. required to suspend the grid or the runners from structural walls, slabs and beams or trusses. Anodized aluminium grid ceiling system from the approved supplier shall be used. All members of the suspension system shall be of sufficient strength and rigidity to carry the ceiling boards or sheets in a true and level plane without exceeding

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a deflection of 1/360th of their span. Samples of suspension system shall be submitted to the Owner/Owner's representative and approval obtained.

Main runners shall be extruded anodized (25 microns) aluminium Tee section of minimum 25 mm x 35 mm size. Secondary runners shall be aluminium Tee section of minimum size 25 mm x 25 mm. Wall angles shall be of minimum size 38 mm x 38 mm. Generally the grid dimensions of 610 mm x 610 mm shall be adopted.

Angle cleats or other suitable fixing device shall be fixed to the structural beam or slab above for fixing of hangers. Main runners shall be hung by M.S. flats or galvanised tie rod at maximum 1.2 m centres. Extra hangers shall be provided at light fixtures that are supported from the ceiling system. The spacing of main and cross runners shall be to suit the ceiling panel size and as recommended by the supplier. The cross runners shall intersect the main runners at perfect right angles and positively locked together with intersection clips. Cutouts for light fixtures, diffusers etc. shall be the exact dimensions and in exact locations.

#### **Suspension system for aluminium panels**

The panels shall be supported on formed carriers, 15 mm wide at top and 43 mm deep, made out of 0.91 min. thick aluminium alloy electrically powder coated in stain black with protruding cars to hold panels in a module of 100 mm (16 mm gap between the panels) at a maximum spacing of 1.3 metres. Carriers shall be suspended from the slab/roof by 4 mm dia galvanised steelwire/rod hangers with height adjustment suspension springs made out of galvanised spring steel hangers, fixed to slab by J hooks and nylon inserts. Edges of the ceiling shall be trimmed with suitable matching edge profiles to cover the gap between the false ceiling and the walls.

#### **Supporting arrangement for false flooring**


The supporting arrangement for particle board false flooring shall consist of pedestal made out of aluminium zinc, alloy rod with check nut into 20 mm. dia and 10 mm thick base plates. The pedestal shall be fixed on the floor @ 600 mm c/c with araldite (or other approved method) including surface preparation. The pedestal heads will receive main end cross M.S. cold roll formed 40 mm x 40 mm x 2.5 mm thick channels including provision of additional angles 50 x 50 x 6 mm and ISMC 100 at cable entries and sides of well as required. The pedestals will have level adjustments to ± 25 mm for levelling. Each pedestal shall be able to support a load of 2500 kg without deformation. All steel framework shall be hot dip galvanised.

The supporting arrangement for cement fill metallic panels false flooring shall consist of seamless pipe 25 mm. outer dia and 12 mm thick base plates. The pipes shall be fixed on the floor @ 600 mm c/c with 50x6 mm metal screw with nylon rowal plug. The pipe heads will have MS check nut and M18x 100 long studs with jackhead zinc plated of size 90x90x4 mm thick over which GI stringer 30x20x1.5 thk having pre punched holes 6 mm dia for the fixing of panels.

#### **Fixing of Ceiling and Floor Panels**

The Contractor shall submit sample panels and get the approval of the Owner/Owner's representative. Installation of ceiling and floor panels shall be strictly as per manufacturer's instruction. The hold down clips for ceiling panels shall be used at the rate of minimum one per 1.2 metre length of perimeter or as per manufacturer's specification. These shall however be omitted in access panels which shall be located as per the instruction of the Owner/Owner's representative.

Finished ceiling and floor shall be at the correct plane and present a pleasing and uniform appearance, free from sags, wraps, disfigured or damaged boards. Joints, exposed grids etc. shall be in true lines and symmetrically placed.

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Finished ceiling and floor shall be at the correct plane and present a pleasing and uniform appearance, free from sags, warps, disfigured or damaged boards. Joints, exposed grids etc. shall be in true lines and symmetrically placed in manner shown on drawings. Cutouts for light fixtures, diffusers, cable ducts etc. shall be to the exact dimensions and in exact locations.

#### 5.5.16 Roof Insulation

##### Scope

This specification covers the requirements in respect of materials and workmanship for under deck roof insulation.

##### Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Indian Standards Institution and all other such as may be published by them during the currency of the contract shall govern in respect of design, workmanship, quality and properties of materials and method of testing.

The relevant available code is listed hereunder:

IS: 8183            Bonded mineral wool.

##### Materials

The materials for insulation shall be resin bonded mineral wool insulation of Group I as per IS: 8183 with aluminium facing.

##### Workmanship

Slotted angle 50 x 50 x 6, 50 mm long shall be fixed to the underside of the slab at 600 mm centres in both direction. The insulation board or rolls shall be fixed to the underside of the slabs at 600 mm centres in both directions with the aluminium foil face at the bottom with a suitable adhesive. The insulation material shall be held in position by means of the 25 mm x 24 SWG net tied to the slotted angles. The joints if any of the wire netting shall be butted and lightly laid down with GI wire.


#### 5.5.17 Water Supply, Drainage and Sanitary Works

##### Scope

This specification covers the requirements in respect of materials, installation and quality for water supply, drainage and sanitary works.


##### Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

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**Roof Drainage System**

IS:1230	Cast iron rain water pipes and fittings
IS:1626	Asbestos cement building pipes, gutters and fittings (spigot and socket type)
IS:1729	Specification for sand cast iron spigot and socket soil, waste and ventilating pipes, fittings and accessories.
IS:1742	Code of practice for building drainage.
IS:2527	Code of practice for fixing rainwater gutters and down pipes for roof drainage Pipes and fittings for sanitary plumbing and drainage
IS:404	Lead pipes
IS:405	Lead sheet and strip
IS:458	Concrete pipes (with and without reinforcements)
IS:651	Salt glazed stoneware pipes and fittings
IS:77	Glazed fire clay sanitary appliances
IS:774	Flushing cistern for water-closets and urinals (other than plastic cisterns)
IS:775	Cast iron brackets and supports for wash basins and sinks
IS:778	Copper alloy gate, globe and check valves for water works purposes.
IS:781	Cast copper alloy screw down bib taps and stop valves for water services
IS:782	Caulking lead
IS:783	Code of practice for laying of concrete pipes
IS:804	Rectangular pressed steel tanks
IS:1172	Code of basic requirement for water supply drainage and sanitation
IS:1239	Mild steel tubes and tubulars and other wrought steel fittings
IS:1536	Centrifugally cast(spun) iron pressure pipes for water, gas and sewage
IS:1537	Vertically cast iron pressure pipes for water, gas and sewage.
IS:1703	Ball valves (horizontal plunger type) including floats for water supply purposes
IS:1711	Self closing taps for water supply purposes
IS:1726	Cast iron manhole covers and frames
IS:1742	Code of practice for building drainage

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IS:1795	Pillar taps for water supply purposes
IS:2065	Code of practice for water supply in buildings
IS:2104	Water meter boxes (domestic type)
IS:2326	Automatic flushing cisterns for urinals (other than plastic cisterns)
IS:2470	Code of practice for installation of septic tanks
IS:2548	Plastic seats and covers for water-closet
IS:2556	Vitreous sanitary appliance (vitreous china)
IS:2963	Copper alloy waste-fittings for wash basins and sinks
IS:3004	Plug cocks for water supply purposes
IS:3006	Chemically resistant glazed stoneware pipes and fittings
IS:3076	Low density polyethylene pipes for potable water supplies
IS:3114	Codes and practice for laying of cast iron pipes
IS:3311	Waste plug and its accessories for sinks and wash basins
IS:3486	Cast iron spigot and socket drain pipes
IS:3597	Methods of test for concrete pipes
IS:4127	Code of practice for laying of glazed stoneware pipes
IS:4346	Washers for use with fittings for water services
IS:4984	Specification for high density polyethylene (HDPE) pipes for potable water supplies, sewage and industrial effluents
IS:4985	Unplasticized PVC pipes for potable water supplies
IS:5219	Cast copper alloy traps ( 'P' & 'S' (Part-I) traps)
IS:5329	Code of practice for sanitary pipe work above ground for buildings
IS:5961	Cast iron gratings for drainage purposes
IS:7634	Code of practice for plastic pipe work for potable water supplies
IS:8008	Injection moulded high density polyethylene (HDPE) fittings for potable water supplies
IS:10124	Fabricated PVC fittings for potable water supplies

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**Materials**

**Sanitary Fittings**

All sanitary fittings shall be procured from approved vendors and shall conform to the requirements of the relevant IS Codes listed above. The sizes shall be as specified in the General Technical Specification, where not specified, the same shall be as per Owner/Owner's representative's approval.

Glazed earthenware fittings shall be of Hindustan Sanitaryware, Parryware or approved equivalent make, white colour and one piece construction. All metallic fixtures like taps, stop cocks, soap holders etc. shall be of Chromium Plated (CP) brass, Jaguar, GEM or approved equivalent make. PVC fixtures shall be of CALIPLAST or approved equivalent make. All wall fittings shall be fixed with wooden cleats and CP brass screws and washers.

**Pipes and Fittings**

Pipes and specials shall be of standard quality conforming to IS:3486.

Stoneware pipes shall conform to IS:651.

RCC pipes for underground sewer shall be P1 class conforming to IS:450.

Cast Iron rain water pipes shall conform to IS:1230.

Water supply lines of GI, PVC, HDPE shall conform to IS:239, IS:4985 and IS:4984 respectively. PVC fittings for water supply lines shall conform to IS:10124.

The Contractor shall submit to the Owner/Owner's representatives samples of all materials, fittings and appliances for approval well in advance of starting the work. All materials, fittings and appliances used in the work shall conform to the approved samples.

**General**

All water supply, drainage and sanitary works shall be executed by a licensed or authorised plumbing supervisor or a license or authorised plumber and shall be in accordance with the requirements of IS:1742 and other relevant codes.


For items such as earthworks, excavation, concrete, brick work, stonework, painting etc. relevant specifications for these shall apply, unless otherwise specified.

Unless otherwise specified, all exposed work such as cisterns, brackets etc. shall be painted with one coat of red oxide paint and two coats of oil paint of approved colour.

The diameter of pipes and fittings wherever mentioned shall mean the internal diameter or nominal bore, unless otherwise specified.

The job shall include the cost of making necessary chases, holes etc, in walls, floors and in other places and also making good on completion of the works. Any damage caused to floors, walls etc. during execution of the sanitary and plumbing works shall be made good by the Contractor at his own cost to the satisfaction of the Owner/Owner's representative.

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### Installation

All execution will be done on the basis of drawings /instruction given by the Owner/Owner's representative. Fittings meant for operation shall be located and oriented to allow easy reach and operation, maintenance, repairs and replacements of pipes, fittings and fixtures must be conveniently possible.

#### Cast iron soil and waste pipe line

##### - Laying

The laying of cast iron pipelines shall commence only after the bottom of the trench at various points have been levelled and aligned in accordance with the drawings. The sides of the trenches shall be as vertical as possible, and the width at the bottom shall be 400 mm wider than the diameter of the pipe. Where joints are made, the trench shall be widened suitably to provide room for caulking joints. Shoring and timbering shall be used where required. For pipes buried in the ground, the Contractor shall take care to maintain always a minimum cushion of earth over the pipes as indicated in the drawings. All pipes, water mains, cables etc. met within the course of excavation shall be carefully protected and supported. All pipes and fittings shall be sounded with a light hammer and check properly to detect any crack or blow holes before laying. The excavated material shall be thrown on one side of trench and the pipes stacked on the other side. The inside of socket and the outside of spigot shall be thoroughly cleaned of all foreign matter before laying. The pipes shall be laid with their socket ends facing the direction of the flow. The pipes shall be lowered in the trenches by a method as approved by the Owner/Owner's representative. The pipes shall then be jointed by caulking as specified under jointing. After each section of the pipeline has been laid it shall be tested for water tightness before backfilling the trench. On successful completion of testing, the trench shall be backfilled with the excavated earth in layers of 200 mm and shall be watered and rammed. Any subsidence occurring in the line of trenches after backfilling shall be repaired by the Contractor at his own cost. Where the pipelines cross roads, the sides of the trenches shall be suitably shored.


When the pipe line has to be laid above ground vertically by the side of wall, it shall be securely fixed to the wall with wooden plugs and nails.

##### - Jointing

The type of jointing for C.I. pipes conforming to IS: 3486 shall be socket and spigot either with molten lead or lead wool and gasket conforming to IS:782.

If the joints used are spigot and socket type, the spigot shall be carefully centred in the socket by one or more laps of clean white hemp spun yarn with about 25 mm overlap. Sufficient yarn only shall be forced into the socket to leave a correct depth of lead for caulking. The pipe shall then be examined again for line and level and the proper depth of each joint shall be tested before running the molten lead. For pouring of molten lead a ring of hemp rope shall be wrapped round the pipe at the end of the socket and the joint shall be covered with stiff damp clay. The rope shall then be removed carefully leaving a V-shaped large hole at the top of the joint to pour the molten lead. Lead shall be poured in one operation only. After a section of convenient length of pipe has been laid, lead shall be caulked sufficiently with caulking tools and hand hammered till the excess lead removed and the joint shall be made neat and clean. Depth of lead in joints from the top of socket shall be 37 mm for 150 mm dia pipes and 25 mm for 100 mm dia pipes.

The type of joint CI pipes conforming to IS:1729 shall be socket and spigot with cement and sand mortar (1:1) and gasket yarn.

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The spigot shall be carefully inserted and centered in the socket by one or more laps of thin clean hemp spun yarn and shall be forced into the socket to leave a correct depth of 30 mm all-round and level and the proper depth of each joint shall be tested before inserting the cement mortar. The joints shall then be carefully be levelled to the edge of the socket. Each joint shall be adequately cured by covering with wet clothes and pouring water at frequent intervals.

The packing ring or washer for the flanged joints shall be rubber for the full diameter of the flange with proper pipe hole and bolt holes cut out suitably. The packing shall be smeared with graphite paste or a mixture of red lead and white lead and shall be introduced between the flanges of both the pipes and nuts tightened in opposite pairs keeping the longitudinal axes of adjoining pipe lines in exactly the same straight line. Lead washers shall be provided along with bolts to prevent any leakage through bolt holes.

**Stoneware pipes**

- **Laying**


The laying of stoneware pipelines shall commence only after the bottom of the trench at various points have been levelled as shown in the drawings. The centre line excavated to correct depth, slope and width at all points. The pipes shall be carefully laid to the alignment, levels and gradients as shown on the drawings. The trench shall be excavated wide enough under the sockets to allow hands to pass for making joints. The pipes between manholes shall be laid truly in straight lines and without any vertical or horizontal deviations on a bed of concrete as shown on the drawings. While laying pipes, portion of concrete under each socket shall be dug and taken off so that the barrel of the pipe gets full support on the concrete bed. Pipes shall be haunched with concrete tangentially upto the crown of the diameter of the pipe as shown on the drawings. When it crosses under a road, the pipe shall be fully encased in concrete as shown on drawings. The Contractor shall take precautions to maintain always a minimum cushion of earth over the pipes as indicated in the drawings. All pipes shall be carefully examined with a light hammer of soundness before laying. After each section of the pipelines has been laid, the joints shall be allowed to set properly and shall be inspected and tested as directed by the Owner/Owner's representative. Backfilling of the trench shall be carried out only after the approval. After testing, the trench shall be backfilled with selected earth in layers of 200 mm and shall be watered and thoroughly rammed. All pipes, water mains, cables etc. met within the course of excavation shall be carefully protected and supported.

When the pipelines cross roads, the trenches shall have vertical sides with suitable shoring. Any subsidence in the line of trench after backfilling shall be repaired by the Contractor at his own cost.

- **Jointing**

The type of jointing for stoneware pipes shall be socket and spigot type. The inside of the socket shall be first painted with a thin layer of cement mortar (1:2) and a gasket of yarn dipped in cement slurry shall be inserted in the socket of the pipe with the wooden caulking tool and wooden mallet in such a way that the gasket shall fully encircle the spigot with a slight overlap. When the spigot end received the gasket, it shall be wrapped round with two or three turns of treated spun yarn at its ends before being inserted into the socket. The rest of the joint shall then be completely filled with cement sand mortar (1:1) having very little water and the joint shall be levelled to form a smooth splayed fillet at an angle of 45°. All excess of cement mortar left inside the pipe joint shall be neatly cleaned off and the joint shall be adequately cured by covering with wet gunny bags and pouring water at frequent intervals. In jointing stoneware pipes, care shall be taken that the pipes are kept concentric and the socket, specially on the underside shall be completely filled with cement mortar. Where settlement of earth is envisaged, the joint shall be made with bitumastic filler or any other materials as approved by the Owner/Owner's representative.

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**Concrete pipes**

- **Laying**

The laying and jointing of pipes shall conform to IS:783. The trench shall be checked for proper level, gradient and alignment before lowering the pipes.

The pipes shall be lowered cautiously to prevent disturbance of the bed and sides of the trench. The heavy pipes shall be lowered by means of proper shear legs, chain pulley blocks or as directed by Owner/Owner's representative. Great care should be taken to prevent sand etc. from entering the pipes.

Laying of pipes shall proceed up grade of slopes. The error of grade shall not be rectified by packing up earth underneath the pipes. If required, concrete shall be used for packing. The ends of the pipes shall be kept closed to keep dirt, mud and foreign materials, out. Adequate provision shall be made to prevent floating of pipe in the event of flooding of trenches. The body of the pipe for its entire length shall rest on an even bed in the trench and places shall be excavated to receive the collar for the purpose of jointing.

- **Jointing**

The type of jointing for concrete pipes shall be with loose concrete collars and the joints shall be packed from either side with spun yarn dipped in cement slurry as specified for jointing stoneware pipes. Stiff cement mortar (1:1) shall be filled from both sides and splayed at an angle of 45o on both sides. The joint shall be adequately cured as specified for joints in stoneware pipes.

**Cast iron rainwater pipes**

Cast iron rainwater pipes fixed to the external walls shall be blocked out atleast 20 mm from the plastered surfaces by means of cast iron bobbins. The rainwater pipes at the roof level shall be fitted with a cast iron bend with a masonry bell mouth of suitable size fitted with a cast iron grating. The bottom of the down pipe shall be fitted with a shoe fixed 150 mm above ground/apron level of the building. The socket and spigots of pipes and fittings shall be jointed as specified for cast iron soil and waste pipe line.

**Galvanised steel water supply pipes**


Screwed galvanised steel pipes shall be jointed with screwed joints and screwed fittings of the same materials as that of the pipes. Any burrs remaining on the pipe ends after the treads are out shall be removed. An approved jointing compound together with a grummet of a few strands of fine yarn shall be used for jointing pipes and fittings. Any pipe threads exposed after jointing shall be painted or in the case of underground piping thickly coated with approved bituminous compound to prevent corrosion.

The depth at which the underground water supply pipe is to be laid be as shown on the drawings. The service pipe passing into or beneath the building shall be laid at least 200 mm below the ground floor level and accommodate in a previously laid sleeve in the structure where it enters the building. The space between the sleeve and the pipe at its entry into and exit from the building shall be filled with a bituminous material for a minimum of 150 mm at both ends.

Piping shall not be buried in walls or floors as far as possible. However, when unavoidable, piping shall be buried for the shortest distance necessary and adequate protection shall be provided against damage.

Galvanised steel piping shall be secured by iron or steel clamps and hooks when fixed on walls.

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All pipe work shall be completely watertight and the joints shall be such that there are no projections of jointing materials or the like in the interior of pipes. Before the pipe line is commissioned, all piping and fittings shall be flushed clean.

**High Density Polyethylene water supply pipes**

All high density polyethylene pipes shall have screwed ends and shall be jointed with screwed fittings of the same materials of that of the pipes. Any burrs remaining on the pipe ends after cutting threads shall be removed. If necessary, an approved jointing compound with a few strands of fine yarn may be used for jointing pipes and fittings. All exposed high density polyethylene pipes shall be installed with PVC saddles screwed on 25 mm thick wooden blocks securely fixed on walls at suitable intervals, not exceeding 1 m. Pipe wherever installed in wall chasing shall be fixed as in the case of galvanised steel pipes.

**PVC water supply pipes**

All exposed pipes shall be installed with PVC saddles screwed on 25 mm thick wooden blocks securely fixed on walls at suitable intervals, not exceeding 1 m. Pipe wherever installed in wall chasing shall be fixed as in the case of galvanised steel pipes.

**Inspection pits and trap pits**

Construction of pits shall commence only after the pipes have been laid in position to true line and levels as shown on the drawings and to the satisfaction of the Owner/Owner’s representative.

- **Inspection pits**

Unless otherwise specified, all inspection pits shall be constructed with rubble masonry in cement mortar (1:4). Half round channels of size suitable for the inlet and outlet pipe diameters shall be formed on the floor of the pit with PCC 1:3:6. The floor of the pit shall be haunched towards the channel as shown on the drawings. Inside of pits shall be finished with cement-sand plaster (1:4) and finished smooth with cement punning. Care shall be taken to avoid unevenness on the surface and sharp bends in the channel. The invert level after finishing shall be as shown in the drawings or as indicated by the Owner/Owner’s representative.

- **Intercepting/master trap pits**

The pits for the glazed stoneware master trap shall be constructed as indicated in the drawings. The construction and finishing of the pit shall be haunched towards the intercepting/master trap.


- **Gully trap pits**

Gully trap pits shall be constructed as indicated in the drawings. The construction and finishing of the pit shall be as described above for inspection pits. The **cast iron grating shall** be set flush with the finished ground/floor level.

**Sanitary appliances**

All sanitary appliances shall be fixed in position rigidly on floor and walls as indicated in the drawings or as directed by the Owner/Owner’s representative. All appliances shall be from the approved manufacturer and of approved colour.

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- **Indian Water Closet - Squatting type (IWC)**

Squatting type water closet shall be fitted on trap and shall be jointed with gasket yarn and cement mortar. Rim of the pan shall be levelled properly and set flush with the finished floor. The pan shall be connected to PVC low level push button/lever type cistern of 10 litre capacity. The flushing cistern shall be supported on a pair of CI cantilever brackets firmly embedded in the wall in cement mortar (1:4) or screwed to wall with suitable plugs. The flush pipe from the cistern shall be 32 mm dia tested quality Chromium Plated (CP) pipe and connected to the pan inlet by means of hemp and putty joint.

- **European Water Closet (EWC)- pedestal type**

Pedestal type water closet shall be rigidly fixed on the finished floor by means of 75 mm long brass screws with suitable plugs. The flushing cistern shall be PVC low level push button/lever type cistern of 10 litres capacity. The cistern shall be supported on a pair of cast iron or rolled steel cantilever brackets firmly fixed on wall with brass screws and suitable plugs. The flush pipe from the cistern shall be 40 mm dia chromium plated brass end and fitted to the closet by means of rubber adopter. The closet shall be provided with double plastic seat cover conforming to IS: 2548 and chromium plated hinges.

- **Urinals**

Standing type urinals shall be firmly fitted on finished wall by means of 50 mm long brass screws and suitable plugs. Height of the lip from the standing point shall be as shown in the drawings. Urinals shall be fitted with automatic flushing cistern of 10/15 litres (2/3 urinals) capacity. Flushing pipes shall be of CP pipes of 25 mm dia and connected to the urinal with 15 mm dia PVC connector fitted with brass cap and lining at one end. The joint to the inlet of urinal shall be neatly finished with putty joints.

The arrangement of waste pipes and discharge to the floor trap shall be as shown on the drawings or as directed by Owner/Owner's representative. For single urinal the discharge may be direct to the floor trap through a 40 mm dia waste pipe. For a range of urinals, the discharge may be collected in a common waste pipe of 50 mm dia leading to the floor trap. Each urinal shall be connected to the common discharge pipe by 40 mm dia waste pipes. Alternatively, the discharge from each urinal through 40 mm dia pipe shall be lead to the 100 mm W.G half round channel laid on the floor leading to the floor trap.

- **Wash hand basin**


Wash hand basin shall be fitted in position to true level on a pair of cast iron brackets plugs. The basin shall be fitted with 15 mm dia approved quality CP pillar tap and 32 mm dia waste fittings. The type of waste pipe and their connections shall be as shown in the drawings or as directed by the Owner/Owner's representative.

- **Sink**

Stainless steel sink of shall be levelled properly and fitted in position on a pair of cast iron cantilever brackets firmly embedded in the wall in cement mortar (1:4). The sink shall be fitted with chromium plated brass waste fittings of standard size. The type of waste pipes and their connections shall be as shown on the drawings or as directed by the Owner/Owner's representative.

- **Other miscellaneous fittings (e.g. mirror, towel rails, soap cases etc.)**

All such fittings shall be of type and sizes specified in General Technical Specification and shall be fitted in position true to line, level and plane as shown on the drawings or as directed by the Owner/Owner's representative.

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### Water tanks

Water storage tanks shall be of SINTEX brand or approved equivalent make, unless otherwise specified.

In case large volume tank is to be constructed, the same shall be of GI, Masonry or RCC. They shall be fitted with a ball valve of the inlet pipe. A mosquito proof overflow pipe shall be fixed to the tank with the pipe invert about 25 mm above the top of water line. Approved type of stop valve shall be provided for every outlet pipe. All outlet and inlet pipes shall be fixed as shown in the drawings. Inside surface of galvanised steel tanks shall be painted with anti-corrosive drinking water paints.

All storage tanks, water supply fittings and pipes before being put into commission shall be disinfected with liquid chlorine by the Contractor at his own cost.

### Testing and Acceptance Criteria

All sanitary appliances and fittings shall be inspected and tested as per the requirements of IS:1742. All defects and deficiencies detected shall be promptly rectified by the Contractor to the satisfaction of Owner/Owner's representative.

### Soil and waste pipe line

On completion of laying, the cast iron, soil, waste and ventilation pipelines shall be tested by the Contractor at his own cost to detect leakages and any other defects in the pipelines.

Test shall be conducted using proper apparatus with attachment for smoke making machine for applying smoke to the pipelines under pressure. Only cotton waste of brown paper soaked in cresote oil shall be used and fired to obtain dense and pungent smoke. While conducting smoke test, top of soil, waste and ventilation pipes shall be kept open till smoke starts coming out of the openings. The openings shall then be securely plugged with expanding rubber or any other approved plug. The floor traps and other openings for connecting sanitary fixtures shall be sealed with water or other approved plug. The floor traps and other openings for connecting sanitary fixtures shall be sealed with water or other approved plug. The entire pipeline shall be tested in suitable sections as directed by the Owner/Owner's representative. The entire length of the pipelines including all joints under tests shall be closely observed for any sign of smoke leakage.


### Galvanised steel water supply pipes

After the laying and fixing of all galvanised steel water supply pipes and fittings are completed, the line shall be slowly and carefully charged with water to a test pressure of 5 kg per sq cm or the specified working pressure plus 50% as may be prescribed by the Owner/Owner's representative. Care shall be taken that air in pipelines is completely exhausted while filling the pipelines with water. This pressure shall be maintained for at least one hour, unless otherwise specified.

### 5.5.18 Tank Pads

#### Scope

This specification covers the requirements in respect of materials, workmanship and quality for bituminous works, crushed rock ring and ring walls for tank pads.

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### Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their later editions published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

IS:383	Coarse and fine aggregating from natural sources for concrete.
IS:2720 Part VII -	determination of water content-dry density relation using light compaction.
IS:2720 Part VIII -	determination of water content - dry density relation using heavy compaction.
IS:2720 Part IV -	grain size analysis
IS:1478	Classification and identification of soils for general engineering purposes.
IS:803	Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded oil storage tanks.
IS:73	Paving Bitumen

### Materials

#### Bitumen

Bitumen used for anti-corrosive layer shall be of grade 80/100 or equivalent.

#### Sand

Sand shall be clean, dry, coarse, hard, angular free from coatings of clay, dust and mix of vegetable and organic materials and shall conform to IS:383 grading Zone II or III. Silt content shall not be more than 5%.

#### Moorum

Moorum for filling shall consist of coarse and granular moorum containing not more than 20% cohesive fines such as clay (grain size less than 0.074 mm). The moorum shall be 20 mm and down size grading and shall be taken from approved quarries.


#### Stone Aggregates for crushed Rock Ring

Stone aggregates for the crushed rock ring shall be 50 mm and down grade size and shall be of granite or such other approved materials.

#### Stone chippings for premix carpet

Stone chippings for premix carpet shall be hard blue granite or approved locally available stone. The grading shall be normally 12 mm down size and 6 mm down size in the ratio 3:2 respectively.

Cement, steel and aggregates for R.C.C. works in dyke wells

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The material specifications for the above shall be the same as in Clause 5.4.5

**Workmanship**

**Sub Grade Preparation**

The surface of the natural soil exposed at the bottom of excavated pit shall be thoroughly compacted by rolling arising 8 - 10 ton road roller or other means as directed by Owner/Owner's representative to obtain 95% of maximum laboratory/ standard proctor dry density for the soil as per IS:2720 part VII. The minimum number of passes shall be five. The rolling shall also be done outside the tank pad area for atleast 1.5 m beyond the edge of tank pad. Relevant clauses in Section for Earthwork shall also apply.

**Sand/Moorum Filling**

The sand/moorum shall be spread in layers not exceeding 15 cm in loose thickness over the areas. Each layer shall be uniform in density, quality of materials and moisture content before compaction. The moisture content shall be within two percent (2%) of optimum moisture content (OMC) on the dry side of OMC as per IS:2720. Compaction of each layer shall be done by mechanical means as per directions of Owner/Owner's representative. Only inaccessible reaches shall be worked manually.

Each layer shall be uniformly compacted to obtain 95% standard proctor density or 85% relative density. If the material fails to achieve the required density, the layer should be reworked with necessary alteration in the composition, so that the required compaction is obtained.

Further layer shall be placed only after the layer has been compacted to the required density. The finished surfaces must be dressed to required grade and slope. Excess material must be removed from compaction site.


**Crushed Rock Ring**

The stone aggregates for the above shall be laid in layers of 150 mm thickness (compacted thickness) and each layer shall be compacted to obtain a hard core ring wall to the satisfaction of Owner/Owner's representative. The surface shall be checked from time to time during spreading and compaction to ensure a finished surface true to levels and grade as per drawings. Use of fine aggregates such as sand or finer stone aggregates may be required to fill voids and pockets to obtain a uniform compacted hard core. Over the final compacted layer of stone aggregate, sand shall be evenly spread and compacted by tamping/ rolling.

**Anti Corrosive Layer**

Anti corrosive layer shall consist of screened coarse sand mixed with 80/100 bitumen or equivalent, 8 to 10% by volume. The bitumen shall be treated to a temperature of 75oC to 190oC with 3% kerosene if required and sand shall be thoroughly mixed with it in mixing drum to give uniform mixture and shall be laid over the compacted surface of the pad in line, grade and levels as shown in the drawings or as directed by the Owner/Owner's representative. Bitumen shall not be treated beyond the temperatures limits given above. The layer shall be tamped to form hard mass of uniform compacted thickness specified. The anticorrosive layer shall be made in one layer for a 50 mm thickness. For higher thickness it should be laid in two layers after application of a tack coat of bitumen. These layers shall be finished to grade as specified.

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### Premix carpet

The crushed rock ring where provided and the areas on which the premix is to be laid (generally the areas exposed to sun & rain) shall be thoroughly cleaned of all dust and loose materials. On the cleaned surface a tack coat at the rate of 1.0 Kg/m<sup>2</sup> of hot bitumen shall be uniformly applied by sprayers. The applied binder shall be evenly brushed. The binder bitumen 80/100 shall be heated to the temperature of about 190°C with 3% kerosene, if required and mixed with stone chippings at the rate of 6.1 m<sup>3</sup> for 400 Kg of bitumen for 100 sq. m of surface of 50 mm thick carpet. Mixing shall continue until the aggregate is well coated.

The premix carpet shall be laid in two layers of 30 mm and 20 mm. After compacting and laying the first layer of 30 mm, a tack coat of hot bitumen at the rate of 1 Kg/m<sup>2</sup> shall be uniformly applied to the surface by means of sprayer and second layer of 20 mm thick shall be laid, tamped and compacted to the satisfaction of the Owner/Owner's representative. Sand shall be spread on the final surface at the rate of 0.5 m<sup>3</sup>/100 m<sup>2</sup>.

### Reinforced Concrete Works for Ring Wall

Reinforced concrete works shall be done as per specifications laid down in Clause 4.5.0.

The ring wall shall be cast in quick succession and completed within a period of maximum 7 days. It is desirable that it is cast in alternate lengths along the perimeter at first keeping the horizontal reinforcements independent on the next cast panels. Intermediate panel lengths shall be cast after 3 days to provide some relief from shrinkage strain.

### Tolerances

The top surface of tank pad shall be to true level & line within the tolerance limit specified below.

- Where concrete ring wall is provided, the differential level shall be within plus or minus 3 mm in any 10 metres of circumference and within plus or minus 6 mm in total circumference.
- Where concrete ring walls are not provided, the differential level shall be within plus or minus 3 mm in any 3 metres of circumstance and within plus or minus 12 mm in the total circumference.

### 5.5.19 Water Bound Macadam (WBM), Roads


#### Scope

This specification covers the requirement in respect of materials, workmanship and quality for road works like sub-grade preparation, sub-base layer, water bound macadam, drains, pipe culverts etc.

#### Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

Specification for road and bridge works of Ministry of shipping & Transport (Roads wing) Published by IRC.

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- IRC -19            Standard specification and code of practice for Water Bound Macadam
- IRC SP 11        Hand Book of quality control for construction of roads and runways
- IS: 458            Specification for concrete pipes
- IS: 783            Code of practice for laying of concrete pipes
- IS: 2720          Methods of test of soil (All parts)

**Sub Grade**

**Excavation**

After the earthwork in cutting and the earthwork in embankments have been done properly up to the final road level with gradients and camber as per drawings and proper consolidation of the filling is completed, earthwork in box cutting shall be taken in hand. Before starting of Box cutting, the Contractor shall obtain Owner/Owner's representative's approval of cutting and embankment work.

The surface of the formation for a width equal to that of the sub-base course shall be properly prepared before any further courses are laid. Surface shall be cut to a depth below the ground level equal to depth of sub-base course due allowance being made for compaction. Preparation of sub-grade also includes removal of any and all foreign substance accumulation and removing undulations up to 150 mm by filling and cutting as required. The sub-grade shall be dressed parallel to the finished profile.

The excavated spoils shall be transported and utilized in filling of low areas or as directed by the Owner/Owner's representative. The filling shall be done in layers or as directed by the Owner/Owner's representative. The filling shall be done in layers of 150 mm and clods and lumps shall be broken and consolidation done to the satisfaction of the Owner/Owner's representative.

In case of presence of weak soil-pockets below the formation, the Contractor shall excavate and remove such soil to an extent as instructed by the Owner/Owner's representative. Extra depth shall then be filled up with 38 mm down stone-metal and voids in metal shall be filled up with moorum. Then, the filling shall be rammed and rolled uniformly with a road-roller of 8 tonnes minimum weight. These operations of removing weak soil pockets and filling with stone-metal shall be done by the Contractor.


If, by mistake the depth of box cutting is made more than required, the Contractor shall make up the extra depth by metal consolidation, as specified above, at his own cost.

After the top layer/WBM course is laid and compacted, the existing surface at the shoulders of the road must be scarified. Fresh quantity of approved earth must be extracted from the surplus earth obtained by box cutting spreading in layers for building up the berms. The layer of earth must be compacted by at least three passes of 8 - 10 tonne rollers. The edges must be well compacted by suitable means to prevent edge slips and the work properly trimmed and dressed.

**Rolling**

After the box cutting is completed, the sub-grade shall be compacted with powered road roller 8-12 tonnes. The roller shall run over the sub-grade till the soil is evenly and densely compacted, to achieve a dry density of not less than 95% of maximum density as obtained from standard proctor compaction test. There shall be a minimum of five (5) roller passes. All the undulations on the surface which develop due to rolling shall be made good with earth and quarry spills as approved by

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Owner/Owner's representative and the sub-grade re-rolled. The top of the sub grade shall be dressed evenly to the required camber and necessary drainage arrangement at the time of rolling shall be provided. Care shall be taken to avoid excessive rolling of the formation. If, after rolling the formation is higher than required, the excess earth shall be removed by carefully cutting and dressing and the formation shall be rolled as specified above. In case after rolling the formation is depressed below the required level, the Contractor shall continue the process of filling and rolling as above till the correct level is attained up to a limit as decided by the Owner/Owner's representative at Contractor's cost.

**Soling (Sub-Base)**

This work shall consist of laying and compacting rubbles or boulders on prepared sub-grade in accordance with the requirements of this specification. The material shall be laid in one or more layers as shown on the drawings and according to lines, grades and cross sections shown on the drawings or as directed by the Owner/Owner's representative.

**Materials**

The materials to be used for the work shall be rubbles or boulders and gravel from approved quarries. The maximum size of stone shall be 150 mm. The length and breadth of stone shall not be more than twice of its depth. The stones shall be hard, tough and durable and free of earth, loam or vegetable matter. The flaky material shall not be used.

**Construction**


The soling shall be laid as per the cross section as shown on the drawing and the finished thickness after consolidation shall be as directed by the Owner/Owner's representative. The boulders shall be laid flat with their broad faces resting over the sub-grade to have good seating. The stones shall be hand packed as close as possible and bedded firmly. The voids in the soling shall be filled with stone chips and small stones and hammered and wedged into position. Gauge pegs shall be driven into indicate the thickness of the stones to be laid. Any hollows formed during rolling shall be filled in with spills during the process of consolidation so as to conform to the gradient, camber and cross section of the road and leave an even finished solid surface.

The soling shall be rolled by a 8 to 12 tons power roller after blinding with approved quality moorum. The shoulder shall be rolled first to wedge the stones firmly at the edges and then rolling shall proceed towards the centre. The rolling shall be done longitudinally at the shoulder and worked towards the centre of the pavement overlapping on each successive trip by at least one-half of the width of the roller while starting and 300 mm width while finishing. In case of super elevated strips, the rolling shall commence from the inner edge and proceed towards the outer edge.

The roller shall be operated at the lowest speed possible. The speed in any case shall not be greater than 3 km per hour. Rolling shall be continued till a satisfactory surface is obtained. Wherever use of power roller is not feasible, suitable hand roller may be used as per instructions of the Owner/Owner's representative.

The soling if not done as per the specification, if instructed by the Owner/Owner's representative the whole soling over the defective portion shall be taken out, re-laid and compacted with a road roller as specified earlier, by the Contractor at his own cost.

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**Sand-Gravel Sub-Base**

The work shall consist of laying and compacting of a mix of sand and gravel in specified proportion over a prepared sub-grade to the required lines, grades and cross-section in layers as per requirement of this specification.

**Materials**

Sand shall be medium hard, strong, free from organic and deleterious matter and shall be from a source approved by the Owner/Owner’s representative. Sea sand shall not be approved.

Gravel shall be clean, well graded and free from any vegetation organic clay or other materials and shall be from a source approved by the Owner/Owner’s representative.

**Construction**

The sand and gravel shall be mixed thoroughly in specified proportions by approved means. The moisture content shall be brought to within two (2) percent of the optimum moisture content for the mixed materials as per IS:2720 (Part viii).

The sand gravel mix shall be spread over the prepared sub-grade in layer not exceeding 200 mm thick (uncompacted thickness) and compacted by power rollers (8-10 tonnes) to achieve 85% relative density. The layer shall be compacted to the required camber, slope and line.

Further layer shall be placed only after the layer already laid has been compacted to the required density and approved by the Owner/Owner’s representative based on the test results. The finished surface shall be dressed to required camber and level and excess material removed and disposed off by the Contractor at his own cost as instructed by the Owner/Owner’s representative.

**Water Bound Macadam (Sub-Base/Base Coarse)**

Water bound macadam shall consist of clean, crushed aggregates mechanically interlocked by rolling and bonded together with screenings, binding material, where necessary and water, laid on a prepared surged or sub-base, as the case may be, and finished in accordance with the requirements of these specifications and in conformity with the lines, grades and cross-sections shown on the drawings or otherwise directed by the Owner/Owner’s representative.

**Materials**


- **Coarse Aggregate**

Coarse aggregate shall be of crushed blue granite. Aggregate shall be hard and durable and shall be free from excess of flat, elongated, soft and disintegrated particles, dirt and other objectionable matter and shall be from a source approved by the Owner/Owner’s representative.

**Crushed aggregate shall meet the following requirements:-**


- i) Flat or elongated pieces shall not be more than 15%.
- ii) Los Angeles Abrasion value shall not be more than 40% or Aggregate Index value shall not be more than 30%. Coarse aggregate shall be graded as follows :

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Size Range	IS Sieve designation	Percentage passing by weight
63 - 40 mm	80 mm	100
	63 mm	90 - 100
	50 mm	35 - 70
	40 mm	0 - 15
	20 mm	0 - 5
<p>Following test shall be conducted on samples of aggregate :</p>		
<p>i) Sieve analysis</p>		
<p>ii) Impact tests</p>		
<p>iii) Water absorption test - Maximum water absorption shall be 1%</p>		
<p>iv) Wetting and drying - The samples shall be subjected to alternate wetting and drying for 3 days and shall not show signs of disintegration.</p>		
<p>- <b>Screenings</b></p>		
<p>Screenings shall generally be of same material as the coarse aggregate and meet the following gradings :</p>		
Size of screening	IS Sieve designation	Percentage passing by weight
10 mm	10 mm	100
	4.75 mm	85 - 100
	150 microns	10 - 30
<p>Where non-plastic material like moorum is specified, the liquid limit and plastic limit of such material shall be below 20 and 6 respectively and the fraction passing 75 microns sieve shall not exceed 10%.</p>		
<p>- <b>Binding Materials</b></p>		
<p>Gravel of suitable plasticity available from local quarries may be used as binding materials and the same shall be approved by the Owner/Owner's representative.</p>		
<p>When sample of the binding material is wetted and squeezed in hand the following characteristics shall be noted:</p>		
<p>i) The material shall be extremely gritty.</p>		
<p>ii) It can be formed into definite shapes that retain their form even when dried.</p>		

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- iii) When the wetted sample is patted in the palm of the hand it will compact into a dense cake that cannot be penetrated easily with a blunt stick.

**Construction**

- **Preparation of Base**

The sub-grade /sub-base to receive the water bound macadam coarse shall be prepared to the specified grade and camber and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm.

- **Inverted Choke**

If the water bound macadam is to be laid directly over the sub-grade, without any other intervening pavement course, a 25 mm course of screenings shall be spread on the prepared sub-grade before application of the coarse aggregate is taken up.

- **Spreading Coarse Aggregate**

The coarse aggregates shall be spread uniformly upon the prepared surface. The spreading shall be done from stockpiles along the side of the roadway or directly from vehicles. In no case shall the aggregate be dumped in heaps directly on the surface prepared to receive the aggregate nor shall hauling over the uncompacted or partially compacted base be permitted.

The surface of the aggregates spread shall be carefully checked with template and all high or low spots remedied by removing or adding aggregate as may be required. No segregation of large or fine particles shall be allowed and the coarse aggregate as spread shall be of uniform gradation with the pockets of fine material.

The coarse aggregate shall not normally be spread more than three (3) days in advance of the subsequent construction operations.


- **Rolling**

Immediately following the spreading of the coarse aggregate, rolling shall be started with three wheeled power rollers of 8 to 10 tonne capacity or tandem roller or vibratory rollers of approved type. The weight of the roller shall depend upon the type of the aggregate and be indicated by the Owner/Owner's representative.

Except on super elevated portions where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre. First the edge/ edges shall be compacted with roller running forward and backward. The roller shall then move inwards parallel to the centre line of the road, in successive passes uniformly lapping preceding tracks by at least one half width.

Rolling shall continue until the aggregates are thoroughly keyed and the creepage of aggregates ahead of the roller is no longer visible. During rolling slight sprinkling of water may be done, if necessary.

Rolling shall not be done when the sub-grade is soft or yielding or when it causes a wave-like motion in the sub-grade or sub-base course. Wherever use of power roller is not feasible, suitable hand roller may be used as per the instructions of the Owner/Owner's representative.

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The rolled surface shall be checked transversely and longitudinally with templates. If irregularities noticed, which exceed 12.5mm when tested with a 3m straight edge, the surface shall be loosened and aggregates added or removed as required and re-rolled until the entire surface conforms to desired camber and grade. In no case shall use of screenings be permitted to make up depressions.

**- Applications of Screenings**

After the coarse aggregate has been rolled, screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motion of hand shovels or by mechanical spreaders, or directly from trucks. Trucks operating for spreading the screenings shall be so driven as not to disturb the coarse aggregate.

The screenings shall be applied at a slow and uniform rate (in three or more application) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms, hand brooms or both. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregate.

The spreading, rolling and brooming of screenings shall be carried out in only such lengths of the road which would be completed within one day's operation.

**- Sprinkling and Grouting**

After the screenings have been applied, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into voids and to distribute them evenly. The sprinkling, sweeping and rolling operations shall be continued, with additional screening as necessary, until the coarse aggregate has been thoroughly keyed, well-bonded and firmly set in its full depth and a grout has been formed of screening. Care shall be taken to see that the base or sub-grade does not get damaged due to the addition of excessive quantities of water during construction.


**- Application of Binding Material**

After the application of screenings, the binding material where it is required to be used shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water, the resulting slurry swept in with hand brooms, or mechanical brooms to fill the voids properly, and rolled during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling of voids, forms a wave ahead of the wheels of the moving roller.

**- Setting and Drying**

After the final compaction of water bound macadam course, the road shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings or binding materials as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam has set. The Owner/Owner's representative shall have the discretion to stop hauling traffic from using the completed water bound macadam course if in his opinion it would cause excessive damage to the surface.

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- **Second Layer of WBM (where specified)**

Before laying the second layer of WBM, the surface shall be scarified and reshaped to the required camber and profiles and all ruts, depressions, pot holes etc. made good. The second layer shall be laid after the surface preparation is approved by the Owner/Owner's representative.

The specification for second layer of WBM shall be similar to the first.

**Pipe Culverts**

**Materials**

The drainage pipes unless otherwise shown on drawings or instructed by the Owner/Owner's representative, shall be made of RCC (Hume pipe) and shall be either Class NP2 or NP3.

Pipe culverts shall be made of reinforced concrete pipe (Hume Pipe) and shall be of class NP2 or NP3 as decided by the Owner/Owner's representative or shown in the drawing. All pipes shall meet the requirements of IS:458 and shall be procured from approved manufacturers with collars as per manufacturers standard specifications. The Bidder shall specifically mention the particular manufacturer's product he proposes to use.

Cement to be used shall be either Portland slag cement with minimum 50 % slag or Portland pozzolana cement.

Aggregate shall be as per IS: 383 - Maximum size shall not exceed one third the thickness of the pipe or 20 mm whichever is smaller. For bedding concrete for laying the pipes, the maximum size of aggregate shall be 38 mm.

Fine aggregate for concrete shall be as per IS: 383.


**Laying of Pipes**

Laying of Hume pipes and collars shall be done as per IS:783. Pipes shall be laid either in trenches or on supports as per drawing and/or Owner/Owner's representative's instructions. All pipe sections and collars shall be inspected carefully for defects before laying in the trenches. Broken or defective pipe shall not be used and shall be properly marked and removed from site as soon as the defects are detected. Pipes shall be laid true to line and grade as specified in the drawings and/or Owner/Owner's representative's instruction. The bedding of the pipes shall be 'First class bedding' or ordinary bedding as per IS:783. The profile of cutting of trenches, free working space provided on each side of the pipe, etc. shall be decided at site by the Owner/Owner's representative as per site condition. Side slope, shoring, bailing out water etc. as required shall be done by the Contractor. Side slips, if there be any, shall be removed by the Contractor. After laying of the pipes are completed, backfilling of the trenches shall be done in layers of 150 mm, clods and lumps broken, watered and compacted with iron rammers to the satisfaction of the Owner/Owner's representative. The surplus spoils shall be transported and filled in low areas within the plant area, as instructed by the Owner/Owner's representative. The filling shall be done as per specification.

All pipes and fittings shall be gradually lowered into the trench or placed on the supports by approved means taking due care not to damage them.

Under no circumstances the pipes shall be dropped into the trench or on supports from a height. The joints of pipes shall be grouted with 1:2 cement - sand mortar and the procedure of jointing shall be as per IS:783.

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Pipes laid in trenches in earth shall be bedded evenly and firmly and as far up the haunches of the pipes as consistent with the load expected to be transmitted from the backfill through the pipe to the bed. This shall be done either by excavating the bottom of the trench to fit the curve of the pipe or by compacting the earth under and around the curve of the pipe to form an even bed.

Where the pipe is laid in trench in rock, hard clay, shale or other hard materials, the space below the pipe shall be excavated and replaced with an equalising bed of concrete (1:4:8 mix), sand or compacted earth as approved by the Owner/Owner's representative. In no place shall the pipe be laid directly on such hard material.

If end protection wall is shown in drawing, the wall shall be constructed with first class quality locally available bricks from approved source. All civil works connected with the protection work, like concrete, brick masonry, plastering etc. shall be done as per relevant Indian Standards and in accordance with approved construction drawings. All materials used shall also conform to Indian Standards.

### 5.5.20 Bitumen Roads

#### Scope


This specification covers the requirement in respect of materials, workmanship and quality for bitumen roads like bitumen macadam, premix carpet etc. Moreover, for specification for base course, sub-base course of roads, the technical specification 5.5.19 (Technical Specification for road works construction roads) shall be referred.

#### Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by Indian Road Congress and Bureau of Indian Standards shall govern in respect of design, workmanship, quality and properties of materials and methods of testing.

Some of relevant available codes are listed here under.

IRC - 47	Standard specification and code of practice for bitumen road.
IRC - 48	Standard specification for bitumen roads surface dressing using pre coated aggregates.
IRC - SP - 11	Hand book of quality control for construction for roads and runaways.
IS:73	Specification for paving bitumen.
IS:217	Specification for cut back bitumen.
IS:454	Specification for digboi type cut back bitumen.
IS:1200	Method of measurement for road work (Part-17) including air field pavements.

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**Execution**

**Tack Coat**

- **Description**

The work shall consists of application of a single coat of low viscosity liquid bituminous material to an existing road surface preparatory to another bituminous construction.

- **Materials**

Binder: The binder used for tack coat shall be bitumen of a suitable grade as directed by the Owner/Owner's representative and conforming to IS:73, 217 or 454, as applicable, or any other approved cutback.

**Construction Operations**

- **Preparation of Base**

The surface on which the tack coat is to be applied shall be thoroughly swept and scraped clean of dust and any other extraneous material before the application of the binder.

- **Application of Binder**

Binder shall be heated to the temperature appropriate to the grade of bitumen used and approved by the Owner/Owner's representative and sprayed on the base at the rate specified below. The rate of spread in terms of straight-run bitumen shall be 5 kg. per 10 square metre area for an existing bitumen treated surface and 10 kg per 10 square metre area for an untreated water bound macadam surface. The binder shall be supplied uniformly with the aid of sprayers.

The tack coat shall be applied just ahead of the oncoming bituminous construction.

**Semigrout (Bituminous Macadam Binder Course)**

This work shall consist of construction, in a single course, 115 mm thickness of compacted crushed aggregates premixed with a bituminous binder, laid immediately after mixing, on a base prepared previously in accordance with the requirements of these specifications and in conformity with the lines, grades and cross sections shown on the drawings or directed by the Owner/Owner's representative.


**Materials**

- **Binder**

The binder shall be straight run bitumen of a suitable grade as directed by the Owner/Owner's representative complying with IS:73.

The aggregates shall satisfy the physical requirements set forth in Table-I.

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**Table I  
Physical Requirements of Aggregates for  
Bituminous Macadam**

Los Angeles Abrasion *	IS:2386	35% Maximum (Part IV)
Aggregate Impact Value *	IS:2386	30% Maximum (Part IV)
Flakiness Index	IS:2386	35% Maximum
Stripping Value	IS:6241	25% Maximum
Water Absorption	IS:2386	2% Maximum value

\* Aggregates may satisfy requirements of either of the two tests


The aggregates for bituminous macadam for different thickness shall conform to the grading A or B given in Tables II & III.

**Table II  
Aggregates Grading for 115 Mm Compacted Thickness  
of Bituminous Macadam**

Sieve Designation	Percent by weight passing the sieve	
	Grading A	Grading B
63 mm	100	
50 mm	90-100	
40 mm	35-65	100
25 mm	20-40	70-100
20 mm	-	50-80
12.5 mm	5-20	-
4.75 mm	10-30	
2.36 mm	-	5-20
75 micron	0-5	0-4

**Table III  
Aggregates Grading for 50 Mm Compacted Thickness  
of Bituminous Macadam**

Sieve Designation	Percent by weight passing the sieve	
	Grading A	Grading B
50 mm	100	
40 mm	90-100	
25 mm	50-80	100
20 mm	-	70-100
12.5 mm	10-30	-
10 mm	35-60	
4.75 mm	-	15-35
2.36 mm	-	0-20
75 micron	0-5	0-4

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- **Proportioning of Materials**

The binder content for premixing shall be 3.5 and 4.0 percent by weight of the total mix for aggregate grading A and B respectively, except when otherwise directed by the Owner/Owner's representative.

The quantities of aggregates to be used shall be sufficient to yield the specified thickness after compaction.

- **Variation in Proportioning of Materials**

The Contractor shall have the responsibility for ensuring proper proportioning of materials and producing a uniform mix. A variation in binder content of  $\pm 0.3$  percent by weight of total mix shall, however, be permitted for individual specimens taken for quality control tests.

**Construction of Operation**

- **Weather and Seasonal Limitations**

Bituminous macadam shall not be laid during rainy weather or when the base course is damp or wet.

- **Preparation of Base**

The base on which bituminous macadam is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross sections as directed by the Owner/Owner's representative. The surface shall be thoroughly swept and scraped clean and free from dust and foreign matter.

- **Tack Coat**

A tack coat shall be applied over the base.

- **Preparation and Transport of Mix.**

Hot mix plant of adequate capacity shall be used for preparing the mix.


The temperature of binder at the time of mixing shall be in the range 150°C - 165°C and that of aggregates in the range 125°C - 150°C provided that the difference in temperature between the binder and aggregate at no time exceed 25°C.

Mixing shall be thorough to ensure that the homogenous mixture is obtained in which all particles of the aggregates are coated uniformly.

The mixture shall be transported from the mixing plant to the point of use in suitable vehicles. The vehicles employed for transport shall be clean and be covered over in transit if so directed by the Owner/Owner's representative.

- **Spreading**

The mix shall be spread immediately after mixing by means of a self propelled mechanical paver with suitable screeds capable of spreading, tampling and finishing the mix to the specified lines, grade and cross sections. However, in restricted locations and in narrow widths, where the available plants cannot operate in the opinion of the Owner/Owner's representative, he may permit manual laying of the mix.

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The temperature of mix at the time of laying shall be in the range 110 Deg - 135 Deg C.

In multilayer construction, the longitudinal joint in one layer shall offset that in the layer below by about 150 mm. However, the joint in the topmost layer shall be at the centre line of the pavement.

Longitudinal joints and edges shall be constructed true to the delineating lines parallel to the centreline of the road. All joints shall be cut vertical to the full thickness of the previously laid mix and the surface painted with hot bitumen before placing fresh material.

- **Rolling**

After the spreading of mix, rolling shall be done by 8 to 10 tonne power rollers or other approved plant. Rolling should start as soon as possible after the material has been spread. Rolling shall be done with care to keep from unduly roughening the pavement surface.

Rolling of the longitudinal joint shall be done immediately behind the paving operations. After this, the rolling shall commence at the edges and progress towards the centre longitudinally except that on super-elevated portions, it shall progress from the lower to the upper edge parallel to the centre line of the pavement.

The initial or breakdown rolling shall be done as soon as it is possible to roll the mixture without cracking the surface or having the mix pick up on the roller wheels. The second or intermediate rolling shall follow the breakdown rolling as closely as possible and be done while the paving mix is still at a temperature that will result in maximum density. The final rolling shall be done while the material is still workable enough for removal of roller marks.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding fresh material. The rolling shall then be continued till the entire surface has been rolled to compaction, there is no crushing of aggregate and all roller marks have been eliminated. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. The roller wheels shall be kept damp if necessary to avoid the bituminous material from sticking to the wheels and being picked up. In no case shall fuel lubricating oil be used for this purpose.

Rolling operations shall be completed in every respect before the temperature of the mix falls below 80 deg C.

Rollers shall not stand on newly laid material while there is a risk that it will be deformed thereby. The edges along and transverse of the bituminous macadam laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it. Wherever use of power roller is not feasible, suitable hand roller may be used as per the instructions of the Owner/Owner's representative.


The bituminous macadam shall be provided with final surfacing without any delay. If there is to be any delay, the course shall be covered by a seal coat before allowing any traffic over it.

**Open Graded Premix Carpet**

- **Description**

This work shall consist of laying and compacting an open-graded carpet of 5 cm thickness in a single course composed of suitable small sized aggregates premixed with a bituminous binder on a previously prepared base, to form a wearing course, in accordance with the requirements of these specifications.

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- **Materials**

- **Binder**

The binder shall be bitumen of a suitable grade, as directed by the Owner/Owner's representative and satisfying the requirements of IS: 73, 217, 454 or other approved cutback as applicable.

- **Aggregate**

The aggregate shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They shall be obtained by crushing rock and be free of elongated and flaky pieces, soft and disintegrated materials and vegetable or other deleterious matter. They shall preferably be hydrophobic type.

The aggregates shall satisfy the quality requirements set forth in Table I except that the Flakiness Index shall be limited to a maximum of 30%.

- **Proportioning of Materials**

The materials shall be proportioned as per quantities given in Table IV.

**Table IV**

Quantities of Materials Required for 10 sq.m.  
of Road Surface for 5 cm Thick open-graded

Premix Carpet

Aggregates of carpet

a)	Stone chippings - 12 mm size; passing 20 cm sieve and retained on 10 mm sieve	0.18 cu.m
b)	Stone chippings - 10 mm size; passing 12.5 mm sieve and retained on 6.3 mm sieve	0.09 cu.m

Binder for premixing (quantities in terms of straight run bitumen)


a)	For 0.18 cu.m of 12 mm size stone chippings at 52 kg per cu.m	9.5 kg
b)	For 0.09 cu.m of 10 mm size stone chippings at 56 kg per cu.m	5.1 kg
	Total	14.6 kg

**Construction Operation**

- **Weather and Seasonal Limitations**

Open graded premix carpet shall not be laid during rainy weather or when the base course is damp wet or when the atmospheric temperature in shade is 16 deg C or below.

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- **Preparation of Base**

The underlying base on which the bituminous carpet is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross section in accordance with Table V as directed by the Owner/Owner's representative. The surface shall be well cleaned by removing caked earth and other foreign matter with wire brushes, sweeping with brooms and finally dusting with sacks as necessary.

- **Tack Coat**

A tack coat complying with relevant clause above shall be applied over the base preparatory to laying of the carpet. Application of tack coat shall, however, not be necessary when the laying of carpet follows soon after the provision of the bituminous course.

- **Preparation of Premix**

Mixers of approved type shall be employed for mixing the aggregates with the bituminous binder.

The binder shall be heated to the temperature appropriate to the grade of bitumen approved by the Owner/Owner's representative, in boilers of suitable design avoiding local overheating and ensuring a continuous supply.

The aggregates shall be dry and suitably heated to a temperature as directed by the Owner/Owner's representative before these are placed in the mixer. After about 15 seconds of dry mixing, the heated binder shall be distributed over the aggregates at the rate specified.


The mixture of binder with chipping shall be continued until the chippings are thoroughly coated with the binder. The mix shall be immediately transported from the mixer to the point of use in suitable vehicles or wheel barrows. The vehicles employed for transport shall be clean and be covered over in transit if so directed.

- **Spreading and Rolling**

The premixed material shall be spread on the road surface with rakes to the required thickness and camber or distributed evenly with the help of a drag spreader, without any undue loss of time. The camber shall be checked by means of camber boards and inequalities evened out. As soon as sufficient length of bituminous material has been laid rolling shall commence with 8 to 10 tonne power rollers, preferably of smooth wheel tandem type, or other approved plant. Rolling shall begin at the edges and progress toward the centre longitudinally, except that on the super elevated portions it shall progress from the lower to upper edge parallel to the centre line of the pavement.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding premixed materials. Rolling shall then be continued until the entire surface has been rolled to compaction and all the roll marks eliminated. In each pass of the roller preceding track shall be overlapped uniformly by at least 1/3 width. The roller wheels shall be kept damp to prevent the premix from adhering to the wheels and being picked up. In no case shall fuel/lubricating oil be used for this purpose. Wherever use of power roller is not feasible, suitable hand roller may be used as per the instructions of the Owner/Owner's representative.

Rollers shall not stand on newly laid material while there is a risk that it will be deformed thereby.

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The edges along and transverse of the carpet laid and compacted earlier shall be cut to their full length so as to expose fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it.

**- Seal Coat**

A seal coat conforming to relevant clause shall be applied to the surface immediately after laying the carpet. No traffic shall be allowed on the road till the seal coat has been placed.

**Seal Coat**

**- Description**

This work shall consist of application of a seal coat (Type-B) for sealing the voids in a bituminous surface laid to the specified levels, grade and camber.

Seal coat shall are of two types as given below:

Type A Liquid seal coat comprising of an application of the bituminous binder followed by a cover of stone chippings.

Type B Premixed seal cost comprising of a thin application of fine aggregate premixed with bituminous binder.

**Materials**

**- Binder**

The binder shall be bitumen of a suitable grade as directed by the Owner/Owner's representative and conforming to the requirements of IS: 73, 217, and 454 as applicable or any other approved cutback.


The quality of binder to be utilized, in terms of straight run bitumen shall be 9.8 kg and 6.8 kg per 10 square metre area for Type A and Type B seal coat respectively.

**- Stone Chippings for Type A Seal Coat**

The stone chippings shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They shall be free of elongated or flaky pieces, soft or disintegrated stone, vegetable or other deleterious matter. Stone chippings shall be of 6 mm size defined as 100 percent passing through 10 mm sieve and retained on 2.36 mm sieve. The quantity used for spreading shall be of 0.09 cu.m. per 10 sq.m. area. The chippings shall satisfy the quality requirements spelled out in Table I except that the upper limit for flakiness Index shall be 30%.

**- Fine Aggregate for Type B Seal Coat**

The fine aggregate shall be sand or fine grit and shall consist of clean, hard, durable, uncoated dry particles and shall be free from dust, soft or flaky material, organic matter or other deleterious substances. The aggregate shall pass 1.7 mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cu.m. per 10 sq.m. area.

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### Construction Operations

#### - Preparation of Base

The seal coat shall be applied immediately after the laying of bituminous course which is required to be sealed. Before application of seal coat materials the surface shall be cleaned free of any dust or other extraneous matter.

#### - Construction of Type A Seal Coat

The binder shall be heated in boilers of suitable design, to the temperature appropriate to the grade of bitumen approved by the Owner/Owner's representative and sprayed on the dry surface in a uniform manner preferably with the help of mechanical sprayers. Excessive deposits of binder caused by stopping or starting of the sprayer or through leakage of any other reason shall be suitably corrected before the stone chippings are spread.

Immediately after the application of binder, stone chippings in a dry and clean state, shall be spread uniformly on the surface, preferably by means of a mechanical gritter, otherwise manually so as to cover the surface completely. If necessary, the surface shall be broomed to ensure uniform spread of chippings.

Immediately after the application of the cover material, the entire surface shall be rolled with a 8 - 10 tonne smooth wheeled roller. Rolling shall commence at the edges and progress towards the centre except in super elevated portions where it shall proceed from the inner edges to the outer. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. While rolling is in progress additional chippings shall be spread by hand in whatever quantities required to make up irregularities. Rolling shall continue until all aggregate particles are firmly bedded in the binder and present a uniform closed surface.

#### - Construction of Type B Seal Coat

Mixers of approved type shall be employed for mixing the aggregates with the bituminous binder.


The binder shall be heated in boilers of suitable design, to the temperature appropriate to the grade of bitumen approved by the Owner/Owner's representative. Also the aggregates shall be dry and suitably heated to a temperature directed by the Owner/Owner's representative before the same are placed in the mixer. Mixing of binder with aggregates to the specified proportions shall be continued till the later are thoroughly coated with the former.

The mix shall be immediately transported from the mixing plant to the point of use and spread uniformly on the bituminous surface to be sealed.

As soon as sufficient length has been covered with the premixed material, the surface shall be rolled with 8 - 10 tonne smooth wheeled power rollers. Rolling shall be continued till the premixed material completely seals the voids in the bituminous course and a smooth uniform surface is obtained. Wherever use of power roller is not feasible suitable hand roller may be used as per the instructions of the Owner/Owner's representative.

#### Opening to Traffic

In the case of Type B seal coat, traffic may be allowed soon after final rolling when the premixed material has cooled down to the surrounding temperature. However, as regards Type A seal coat traffic shall not be permitted until the following day.

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### Repair of Existing Roads

Pot holes or patches and ruts in existing bitumen road, concrete road and WBM road shall be repaired by removal of all loose material by cutting in rectangular patches and replacing with suitable materials. The repair shall be done as under:

Pot holes, patches and ruts shall be drained of water and out to regular shape with vertical sides, and then be filled either with

- i) Coarse aggregate and screenings conforming to the specification for water bound macadam and compacted with rollers or other approved rammer

or

- ii) premixed material conforming to the specification for open graded premix carpet and compacted with rollers or other approved means after painting the sides and bottom of the holes with a thin application of bitumen or a combination of both as directed by the Owner/Owner's representative.

Payment for (i) shall be done as per items for water bound macadam and for (ii) as per item for open graded premix carpet. Cutting removal of materials shall be paid under dismantling items.

In case, however it is found that there has been damage to the granular sub-base as well, the area of the damaged surface shall be repaired by removal of all loose materials, out to regular shape with vertical sides and relaid with graded material as per specification of granular sub-base and then surfaced with water bound macadam as per specification for the same.

Further any making up the level of existing soling shall also be done as per procedure given above for repair of granular sub-base and as directed by the Owner/Owner's representative. Measurements and payment will be based on the compacted volume only. The rate will be worked out based on quoted rates for soling of specified thickness.


### Quality Control & Tolerance

The Contractor shall establish and maintain quality control for the various aspects of the work, method, materials and equipment used.

All works performed shall conform to the lines, grades, cross sections and dimensions shown on the drawings or as directed by the Owner/Owner's representative. Permitted tolerances for roadwork's are described hereinafter.

- i) **Horizontal Alignment :**

Horizontal alignments shall be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the carriageway as constructed shall be correct within a tolerance of  $\pm 25\text{mm}$  therefrom. The corresponding tolerance for edges of the roadway and lower layers of pavement shall be  $\pm 40\text{mm}$ .

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ii) **Longitudinal Profile :**

The levels of the sub grade and different pavement courses as constructed, shall not vary from those calculated with reference to the longitudinal and cross-profile of the road shown on the drawings or as directed by the Owner/Owner's representative beyond tolerances mentioned below :


Sub-grade	± 25mm
Sub-base	± 20mm
Base course	± 15mm
Wearing course	± 10mm

Tolerance in wearing course shall not be permitted in conjunction with the positive tolerance for base course if the thickness of the former is thereby reduced by more than 6mm.

iii) **Surface Regularity of Sub grade and Pavement courses :**

The surface regularity of completed sub-bases, base courses and wearing surfaces in the longitudinal and transverse directions shall be within the tolerances indicated in Table V.


The longitudinal profile shall be checked with a 3 metre long straight edge, at the middle of each traffic lane along a line parallel to the centre of the road. The transverse profile shall be checked with a set of three chamber boards at intervals of 10 metres.

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**Table - V  
Permitted Tolerances of Surface Regularity for Pavement Courses**

SI	Type of construction	Longitudinal Profile with 3 metre straight edge Cross Profile					
		Maximum Permissible undulation mm	Maximum number of undulations permitted in any 300 metres length exceeding (mm)				Maximum permissible variation from specified profile under camber template (mm)
			18	12	10	6	
1	Earthen sub grade	25	30	-	-	-	15
2	Granular sub base	15	-	30	-	-	12
3	Water bound macadam with oversize metal (40-90 mm size)	15	-	30	-	-	12
4	Water bound macadam with normal size metal (20-50mm and 40-63 mm size), Bituminous penetration Macadam	12	-	-	30	-	8
5	Surface dressing ** (two coat over WBM (20-50 mm or 40-63 mm size metal), bituminous penetration macadam or built-up spray grout	12	-	-	30	-	8
6	Open graded premix carpet, mix seal surfacing	10	-	-	-	30	6
7	Bituminous macadam	10	-	-	-	20***	6
8	Semi-dense carpet	10	-	-	-	20***	6
9	Asphaltic concrete	8	-	-	-	10***	4
10	Concrete pavements	8	-	-	-	10***	4

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Notes

- 1 \*\* For surface dressing in all other cases, the standards of surface evenness will be the same as those for the surface receiving the surface dressing.
2. \*\*\* These are for machine laid surfaces. If laid manually due to unavoidable reasons, tolerance upto 50% above these values in this column may be permitted at the discretion of the Owner/Owner's representative. However, this relaxation does not apply to the values of maximum undulation for longitudinal and cross profiles mentioned in columns 3 and 8 on the table.
3. Surface evenness requirements in respect of both the longitudinal and cross profile should be simultaneously satisfied.

**5.5.21 Steel Chimney**

**SCOPE**

This specification covers the specific requirements for construction of Steel Chimney. General construction requirements shall be as per other standard specification included in section 5.3.7 In case of conflict between this specification and other specification, the requests given in this specification shall provide.


**CODES AND STANDARDS**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest additions as published by Bureau of Indian Standards and all other such as may be directed published by them during currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed here under :

- |          |  |
|----------|--|
| IS: 6533 | Code of Practice for Design and Construction of Steel Chimneys   |
| IS: 800  | Code of practice for use of structural steel in general building construction  |
| ICAO     | International Civil Aviation Organisation (ICAO).  |
| DGCA     | Instructions of Director General of Civil Aviation, India.   |
| BS: 4076 | Specifications for steel chimneys  |
| CICIND   | Model code for concrete chimneys   |
| ASCE     | Design and Construction of steel chimney liners prepared by Task Document committee on steel chimney liners. Fossil power committee (Power division published by ASCE-1975). |

**GENERAL**

Contractor shall provide and maintain at the site necessary number and type of machinery and equipment including survey instruments in good working condition for proper setting out and timely completion of the works covered under this specification. All arrangements for transporting the equipment to and from the site shall be done by the Contractor at his own expense.

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It shall be ensured by the Contractor that work shall proceed uninterrupted even in the event of power failures. As such, adequate number of diesel operated equipment (such as concrete mixers, vibrators, etc.) shall be provided by the Contractor, as an alternative arrangement, in case, electrically operated equipment are proposed to be brought to site.

All materials supplied by the Contractor shall be of the best quality and shall conform to this specification. Approval in writing shall be obtained from Owner/Owner's representative, before any alternative or equivalent material is proposed to be used by the Contractor.

Contractor shall furnish Manufacturer's test certificate for the materials supplied by him. Where such certificates are not available, and where the Owner/Owner's representative so desires the specimen from the materials supplied to site shall be got tested at a recognized and approved testing laboratory at Contractor's cost.

**MATERIAL, CONSTRUCTION REQUIREMENTS & SPECIFICATIONS**

**Material**

**Structural Steel**

The structural steel to be used for steel chimney shall be as per IS-2062 Grade-A unless specified otherwise in tender drawings.

Welding electrodes shall be of a make approved by Owner/Owner's representative. All electrodes shall conform to IS-814 unless specified otherwise to suit the requirement of shell plate and welding procedure. Contractor shall conduct all tests at site, as directed by Owner/Owner's representative to get his approval for use on Job. Manufacturer's batch certificates shall be submitted at least 2 weeks prior to commencement of welding.

**Base Plate and Holding Down Bolts**

The material shall conform to the requirement of IS-2062 Grade-A and IS-432 Grade-I unless specified otherwise in tender drawings.

**Concrete work in Foundation**

This shall conform to provisions of clause No. 5.3.5

**Receipt and Storing of Material**

All steel parts furnished by supplier shall be checked, sorted out, straightened, and arranged by grades and qualities in stores.


All sections shall be free from surface defects such as pitting, cracks, laminations, twists etc. Use of defective materials shall not be permitted and all such defective material shall be removed from the site immediately.

Welding electrodes shall be stored separately by qualities and lots inside a dry and enclosed room, in compliance with IS-9595 and as per instructions given by the Owner/Owner's representative. Electrodes shall be kept perfectly dry to ensure satisfactory operation and weld metal soundness.

**Fabrication and Erection**

All fabrication and erection shall be done in accordance with IS-800, IS-9595 and based on the fabrication drawings adhering strictly to work points and work lines on the same.

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All connections shall be welded connections except for ladders and platforms unless specified otherwise. Welding shall be done as per IS-9595. Welding procedures shall be conducted and approved as per IS-7307. Approval of welders shall be as per IS-7310.

The vertical butt weld seam shall be staggered at about 120° between adjacent sections of chimney shell.

Any defective material used shall be replaced by the contractor at his own expense.

Any faulty fabrication pointed out at any stage of work shall be made good by the contractor at his own cost.

Radiography examination shall be carried out to a minimum aggregate weld length of 3 meters in a chimney. However, the weld length radiographed shall not be lower than 5% of total weld length of the chimney.

Atleast one spot of 300mm length shall be radiographed for each thickness produced.

If the random radiography of a weld in any joint reveals unacceptable defects, two further welds in the group represented by the weld shall be radiographed to the same extent. If these further welds show no unacceptable defects, the group of welds represented by the weld shall be accepted. However, the first defective weld shall be repaired. If one of the two further welds show unacceptable defects, each weld in the group shall be radiographed. Unacceptable welds shall be repaired and then radiographed.

Radiography shall be carried out using x-ray or Gama ray as decided by the Owner/Owner's representative.

**PAINTING**

All painting work shall be carried out with the best quality of materials and workmanship and in accordance with the best engineering practice and instructions of the Owner/Owner's representative. The compatibility of the paint system shall suit the environment envisaged in and around the plant and confirmed by the paint manufacturer.

**Surface preparation**

The surface to be painted shall be cleaned by chipping, scraping hammering and wire brushing. On completion of cleaning the detached rust, mill scale and other deleterious material shall be removed by clean rag and/or washed by water or steam and thoroughly dried with compressed air jet if required before application of paint.

**Internal surface painting**

**Unlined Chimney Shell**


One coat of suitable priming paint to the interior surface shall be provided.

If required suitable protective treatment shall be used to withstand the corrosive, abrasive and thermal effects of the flue gases.

**Lined Chimney Shell**

If required one coat of a suitable priming paint shall be used followed by two coats of a finish paint or paints applied in accordance with the instructions of the manufacturer.

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**External surface painting**

The outer surface shall be given two coats of epoxy zinc chromate primer followed by two coats of epoxy high build finish coating of approved quality and shade. Where aviation warning signals are required, top 20m of the outer face of the chimney shell shall be painted with two coats of above finish coat of more than one colour in horizontal alternate bands of minimum 5m width to give a perfect contrast. The bands at extremities shall be of darker colour.

**Structural Steel Members**

All structural steel works such as walkways, platforms, handrails, ladders etc. shall be given two coats of high build chlorinated rubber zinc phosphate primer followed by two coats of chlorinated rubber paint of approved quality.

**CHIMNEY FOUNDATION**

Concreting of the foundation (pile cap) shall be carried out in segments only after the steel reinforcement for the entire foundation has been placed and tied in position. Only vertical construction joints with joggles shall be permitted between any two segments. Horizontal construction joints shall not be permitted.

**5.5.22 Fencing & Gate**

**Scope**

This specification covers the requirements in respect of materials, workmanship and quality for chainlink/barbed wire fencing fixed on M.S. angle posts or RCC precast posts.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

- IS:278 Galvanised steel barbed wire for fencing
- IS:1161 Steel tubes for structural purposes
- IS:2062 Steel for general structural steel purposes
- IS:2721 Galvanised steel chainlink fencing

**Materials & Installation**


**Angle Iron Post**

Angle Iron Post shall be rolled angle section conforming to IS:2062 and shall be double dip galvanised.

**Precast Concrete Posts**

Concrete mix shall be M20 as per IS:456. Reinforcement shall be M.S. and/or torsteel bars.

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Posts shall be cast in smooth steel forms made to correct dimensions as per drawing and concrete shall be compacted by table vibrators or needle vibrator to give smooth finish. Curing of concrete shall be done by submerging the posts in water tank for minimum 15 days.

Precast posts shall be installed in PCC 1:3:6 foundation, with a minimum embedment depth of at least 600 mm. Damage to the post shall be avoided during installation of the posts in position, aligning and levelling.

Diagonal post bolted to the vertical posts shall be provided at every eighth bay and on either side of the corner posts. Spacing of the posts shall be not greater than 3 m or as per drawing whichever is less.

All hardware used shall be of hot-dip galvanised steel.

**Chain link fence**

Chainlink shall conform to IS:2761. It shall be procured in rolls of appropriate length and width and shall consist of 10 G hot dip galvanised steel wires woven in the form of zigzag mesh giving an opening size of 50 mm square.

Chainlink shall be secured to the posts with 6 mm dia GI hooks/rings.

Tension wire shall be provided passing through the mesh at top, centre and bottom of the erected chainlink mesh and shall be of 3 mm dia hot dip galvanised wire and shall be stretched to keep the chainlink in taut position. 25 mm x 6 mm GI flat stretcher bar shall be provided at the end posts to tie the tension wires.

**Barbed wire fence**

Barbed wire shall conform to IS:278


Barbed wire shall be made from hot dipped galvanised wire of 12 G, 2 ply with barbs of 16G spaced at 100 mm.

Barbed wire shall be procured in bundles of standard weights and shall be fully stretched across the posts and secured with G.I. hook bolts and washers.

Spacing of horizontal wires shall not be greater than 225 mm or as specified in the drawing. Diagonal wires shall be provided in each bay between two adjacent posts. No wire shall be left loose or sagging.

**Gate**

Gate shall be fabricated out of tubular sections conforming to IS:1161 and shall be hot dipped galvanised. Outer frame shall be 65 NB (medium) tube and diagonal 50 NB (medium) tube. 50 mm sq. welded mesh with 4 mm dia GI wire fabric shall be welded to 25 mm x 6 mm thick GI flat which in turn shall be welded to the outer tubular frame. The gate shall be provided with 20 mm wide x 80 mm dia flat M.S. roller at the bottom. The gate frame shall be fixed to GI tubular post or RCC post.

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### 5.5.23 Concrete Roads and Pavements

#### Scope

This specification covers the requirement in respect of materials, workmanship and quality for concrete roads and pavements. However, for general requirements, testing etc. the technical specification for plain & reinforced concrete work shall be referred.

#### Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest edition as published by Indian Road Congress and Bureau of Indian Standards shall govern in respect of design, workmanship, quality and properties of materials and method of testing.

Some of the relevant available codes are listed here under :

IS:269	Ordinary and low heat Portland cement
IS:455	Specification for Portland slag cement
IS:456	Code of practice for plain & reinforced concrete
IS:1200	Method of measurement for road work including air field (Part-17) pavements
IS:1489	Specification for Portland pozzolana cement
IS:1838	Specification for performed fillers for expansion joints in concrete pavement and structures.
IS:1834	Specification for hot applied sealing compounds for joints in concrete
IS:6509	Code of practice for installation of joints in concrete pavements
IS:8112	Specification for 43 grade ordinary Portland cement
IRC:15	Standard specification and code of practice for construction of concrete roads
IRC:58	Guidelines for the design of rigid pavements for highways


#### Materials

Cement to be used shall be either Portland slag cement with minimum 50 % slag or Portland pozzolana cement.

This should comply with the requirements of IS:269, IS:455, IS:1489 or IS:8112

#### Aggregates (General)

Aggregates should comply with the requirements of IS:389 - Specification for coarse and fine aggregates from natural sources for the concrete work. In order to make good the concrete for roadwork it is important to avoid crushed aggregates of poor particle shape. Weather rock, and very angular, flaky or splintery aggregates should not be used.

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### Coarse aggregates

This should be furnished in at least two separate sizes with separation at 20 mm when combined material graded from 5 to 38 mm is specified and at 25 mm when combined material graded from 20 to 50 mm is specified. Gap graded single sized coarse aggregate as alternate to the continuously graded may be used particularly where grading of fine aggregate is fine to very fine.

### Fine aggregate

Fine aggregate shall be natural sand and should comply with IS:383. Bulking due to presence of moisture in the fine aggregate should be accounted for when the volumetric batching is employed.

### Water

Water is used in mixing or curing of concrete shall be clean and potable quality.

### Reinforcement

#### Bar mats

This shall conform to the requirements of IS:432/IS:1786/IS:1139. The bars shall be of the size and spacing shown on the plans. All junctions of longitudinal and transverse bars shall be securely tied or welded together.

### Load transfer devices

Dowel and tie bars shall be of plain round steel bars conforming to the requirements of IS:432.

### Expansion joint filler

The material for filling the expansion joints shall be of premoulded, non-extruding and resilient type of approved quality. The premoulded joint filler shall be of thickness shown on the drawings or as stated in the bill of quantities. It shall be 25 mm less in depth than the thickness of the slab and of the full width between road forms. Holes to accommodate dowel bars shall be bored or punched out accurately. The joint filler shall comply with the requirements of IS:1838 - Specification for Preformed Fillers for Expansion Joints in concrete, non-extruding and resilient type (bitumen impregnated fibre).

### Joint sealing compound


The sealing compound shall comply with the requirements of IS:1834 - Specification for Hot Applied Sealing Compound for joints in concrete.

### Waterproofing under layer

Waterproofing paper used as under layer be of a brand of approved quality. The paper shall be unrolled with an overlap of not less than 10 cm.

### Forms

All side forms shall be of mild steel unless use of wooden sections are specifically permitted. The steel forms shall be of M.S. channel sections and their depth equal to the thickness of the pavements.

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The sections shall have a length of at least 3 m except on curves where shorter sections may be used. Side shuttering shall be provided at curves as per the drawings or as directed. When set to grade and staked in place, the maximum deviation of the top surface of any section from a straight line shall not exceed 3 mm in vertical plane and 5 mm in horizontal plane. The method of connection between sections shall be such that the joint formed shall be free from movement in any direction. the use of bent, twisted or worn out forms will not be permitted. At least 3 stake pockets for bracing pins or stakes shall be provided for each 3m of form and the bracing and support must be ample to prevent the springing of the forms under pressure of the concrete, or the weight of machinery operating on the forms, Contractor shall arrange for sufficient number of forms so that the forms in position are not disturbed within 12 hours of concreting or longer if in the opinion of the Owner/Owner's representative it would be necessary.

**Workmanship**

**Form setting**

Forms shall be jointed neatly and shall be set with exactness to the required grade and alignment. After the forms are placed and aligned, the earth under the base of the form shall be thoroughly damped in an approved manner. Sufficient rigidity shall be obtained to support the forms in such a position during the entire operation of compaction and finishing. All forms shall be cleaned and oiled each time before they are used.

**Placing of reinforcements**

The overall dimensions of the bar mats shall be such that when properly placed into the work, the extreme longitudinal wires of the mat will be located not less than 50 mm nor more than 100 mm from the edges of the slab. Except for dummy joints, the length of the bar mat shall be such that when properly placed into the work, the reinforcement will be clear of transverse joints by not less than 50 mm and not more than 100 mm when measured from the centre of the joint to the ends of the longitudinal wire of the fabric.

While overlapping the bar mats in either direction, the overlap shall be at least equal to the spacing between the bars in the respective direction.

The bar mats shall be placed in position as shown on the drawings. For placing the top layer of the reinforcement, the first stage of concreting shall be brought up to the level of the reinforcement and lightly compacted by a screed vibrator to obtain uniform level. The reinforcement bar mats shall then be placed on the compacted layer of the concrete and then the remaining depth shall be filled in with concrete. The time lag between laying of the two courses shall not exceed the initial setting time of the cement used. Displacement of the reinforcement during concreting operation shall be prevented.


**Fixing dowel bars**

The dowel bars in expansion joints and transverse construction joints shall be placed and supported in such a manner that they will be truly parallel with the gradient and the centreline to the pavement, and they shall be remain in position during the placement and compaction of the concrete. They shall be placed at the mid depth of the slab and the drawings. Half length of the dowel bars shall be painted with one coat of hot bitumen of approved make or equivalent as shown on the drawings or as directed by the Owner/Owner's representative.

**Fixing tie bars**

Tie bars in longitudinal joints shall be placed approximately the mid depth of the slab and shall be securely held in the slabs on both sides of the joints.

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### Transporting and placing of concrete

The concrete shall be mixed in quantities required for immediate use and shall be deposited in position to the required depth and width of the pavement, sections, in successive batches and in continuous operation without the use of intermediate forms or bulk continuous between joints. The spreading shall be as uniform as possible to avoid re-handling of concrete.

### Compaction and finishing

The surface of the pavement shall be compacted either by means of power driven finishing or by a vibration screed. For areas where the width of the slab is very small, hand compaction and finishing may be adopted. Immediately after the tamping or screeding has been completed and before the concrete has hardened the surface shall be inspected for irregularities with a profile checking template and any needed corrections made by adding or removing of concrete followed by further compaction and finishing.

### Floating

As soon as practicable after the concrete has been struck off and a compacted it shall be further smoothed and compacted by means of longitudinal float operation from a foot bridge.

### Straight edging

After the longitudinal float has been completed and excess water has been disappeared but while the concrete is still plastic, the slab surface shall be tested for trueness with a 3 metre straight edge swung from handles 1 metre longer than one half width of the slab. Any depressions found shall be filled immediately with freshly mixed concrete, struck, compacted and refinished. High areas shall be cut down and refinished. No extra payment shall be made for the removal of the rejected concrete and for laying of the fresh concrete. Unless otherwise specified, and for laying of the pavement surface shall be obtained by belting or brooming or by a combination of both as directed by the Owner/Owner's representative.


### Edging

After belting and / or brooming has been completed, but before the concrete has taken its initial set, the edges of the slab shall be carefully finished with a edger of 6 mm radius and the pavement edge shall be left smooth and true to line.

### Joints

#### Expansion Joints

Expansion joints shall be formed at the intervals shown on the drawing at right angles of the longitudinal axis of the pavement. The width of the joint shall be as shown on the drawing and shall be straight, truly vertical and shall extend from the bottom of the slab. The expansion joint shall be filled with an approved pre-moulded joint filler, which shall extend from the bottom of the slab to 25 mm below the finished surface of the concrete. A timber or metal cap shall be fitted temporarily on the top of the joint filler and the top of this cap shall be flush with the finished surface. Care shall be taken that filler and the cap are set accurately in position and are maintained in position during placing and compaction of concrete. After the pavement has been struck off and finished the metal cap shall be removed. Under no circumstances shall any concrete be left above the expansion joint material or across the joint at any point. After about 15 days of concreting the cavity on the top of the joint filler shall be carefully cleaned of all loose materials and sealed with an approved joint sealing compound. the sealing shall not be done until the concrete is quite dry. The sealer and any

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primer required shall be applied strictly in accordance with manufacturer's instructions. The joints shall be sealed flush with the surface of the concrete. The end of the sliding half of the dowel bar shall be provided with a PVC or G.I. sheets cap at least 75 mm long and minimum 25 mm length of this cap shall be filled with cotton waste dipped in hot bitumen as shown on the drawings.

**Longitudinal and transverse construction joints**

These shall be of top chamfered and sealed type and shall be formed by placing the concrete against the face of the slabs concrete earlier. The face of the old concrete slabs shall be painted with bitumen before placing of fresh concrete.

Tie bars shall be used at construction joints and shall be of the dimensions and at spacings as shown on the drawings.

**Curing**

Immediately after finishing operations have been completed the entire surface of the newly laid concrete shall be covered against rapid drying and cured in accordance with the following methods.

Failure to provide sufficient cover material of whatever kind required or inadequate supplies of water to take care of both curing as well as other requirements shall be adequate cause for immediate suspension of concreting.

**Initial curing**

Immediately after completion of finishing operations, the surface of the pavement shall be entirely covered with wetting burlap, cotton or jute mats. The mats used shall be of such length (or width) that as laid they will extend at least 450 mm beyond the edges of the slab. the mats shall be placed so that the entire surface and both the edges of the slab are completely covered. The covering shall be placed as soon as the concrete has set sufficiently to prevent marring of the surface. Prior to being placed, the mats shall be thoroughly saturated with water and shall be placed with the wettest side down. The mats shall be so placed and weighed down as to cause them to remain in intimate contact with the surface covered, and the covering shall be maintained fully wetted and in position for 24 hours after the concrete has been placed or until the concrete is sufficiently hard to be walked on without suffering damage. Water shall be gently sprayed so as to avoid damage to the fresh concrete. If it becomes necessary to remove a mat for any reason, the concrete slab shall not be exposed for a period of more than half an hour.


Worn burlap or burlap with holes will not be permitted. Burlap reclaimed from previous use other than curing concrete shall be thoroughly washed prior to use for curing purposes. If burlap is furnished in strips, the strip shall be laid overlap at least 150 mm. Burlap shall be placed from suitable bridges. Walking on freshly laid concrete to facilitate placing burlap is not permitted.

**Final curing**

Upon removal of the burlap the slab shall be thoroughly wetted and then finally cured as under :

“Exposed edges of the slab shall be banked with a substantial berm of earth. Upon the slab shall then be laid a system of transverse and longitudinal dykes of clay about 50 mm high immediately covered with a blanket or sandy soil free from stones to prevent the drying up and cracking of clay. The rest of the slab shall then be covered with sufficient sandy soil so as to produce a blanket of earth not less than 37 mm depth after wetting. The earth covered shall be thoroughly wetted while it is being placed on the surface and against the sides of the slab and kept thoroughly saturated with water for 14 days and thoroughly wetted down during the morning of the 15<sup>th</sup> day and shall thereafter remain in place until the concrete has attained the required strength and permission is given, the covering shall be removed and the pavement cleaned and swept. If the earth covering

FORMT9-P REV-A (MUM)

	<b>Subject</b>	<b>Doc. No.</b>	<b>Rev.</b>	<b>Vol. / Sec.</b>
	<b>BID PACKAGE FOR COMBINED CYCLE CAPTIVE POWER PLANT AT HAZIRA PLANT, GUJARAT</b>	<b>5111168-ME-SPC-100-001</b>	<b>R1</b>	<b>III / 5</b>
				<b>Sheet No.</b>
				<b>851</b>

becomes displaced during the curing period, it shall be replaced to the original depth and shall be re-saturated”.

**Removing of Forms**

Forms shall not be removed from freshly placed concrete until it has set at least 12 hours. They shall be carefully removed and in such a manner that no damage will be done to the edges of the pavement. After the forms have been removed, the ends of all joints shall be cleaned and any honeycombed areas painted up with 1:2 mortar, after which the sides of the slabs shall be covered with earth to the level of the top of the slab. All ditches and drains shall be so placed as to provide effective drainage.

**Opening to Traffic**

Traffic shall be excluded from the newly constructed pavement for a period of 28 days. Before the pavement is opened to traffic it shall be cleaned and the joints shall be filled and trimmed or topped out as required. The joint or line of separation between adjacent strips or slabs of concrete, when the pavement is constructed in lanes or strips, shall be cleaned and filled with bituminous material as directed.

FORMT9-P REV-A (MUM)

Bharat Heavy Electricals Ltd.  
Doc. No. TB-383-607-003 R-1

**TECHNICAL SPECIFICATION FOR CIVIL WORKS OF 66 KV GIS AT ONGC HAZIRA  
CCCP (1X51MW)**

**SECTION-4**

**SCHEDULE OF TECHNICAL DEVIATION.**

**BHEL ENQUIRY. NO:**

**BIDDER: OFFER REFERENCE:**

**6.1 Deviations**

Tick

YES

NO

If yes,

<b>S.No.</b>	<b>Deviation</b>	<b>Clause No.</b>
1		
2		
3		
4		
5		
6		
7		
8		
9		

(Signature & Seal of Bidder)