



**2 X 500 MW MALWA  
THERMAL POWER PROJECT**

Doc Name. Basic Engineering Design Data  
Doc No. MALWA-A-TP-G-020



MP Power Gen. Co. Ltd.

FOR BID

L&T - Sargent & Lundy

**BASIC ENGINEERING DESIGN DATA**

**END USER** MADHYA PRADESH POWER GENERATING  
COMPANY LIMITED (MPPGCL)

**LTSL PROJECT No.** T 408000

**LTSL DOC. No** MALWA-A-TP-G-020

**REVISION CERTIFICATION**

REV NO.	DATE OF ISSUE	PREPARED					REVIEWED					APPROVED
		MECHANICAL	ELECTRICAL	CIVIL	INSTRUMENTATION	PROCESS	MECHANICAL	ELECTRICAL	CIVIL	INSTRUMENTATION	PROCESS	
P0	31/7/06											
A	15/9/06											
B	04/5/07											



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## 1.0 GENERAL

### 1.1 Introduction

The power project being proposed by Madhya Pradesh State Electricity Board / Madhya Pradesh Power Generating Company Limited., in the vicinity of Malwa Plateau of the western region is presently conceived to be a coal based power station comprising of two units of 500 to 600 MW capacity each.

The coal for the power station shall be taken from Wardha Coal Mines of Western Coalfields Ltd.(WCL) or Bilaspur / Sohagpur Coal Mines area of South Eastern Coal fields Ltd (SECL). The lower average Gross Calorific Value of 3200 Kcal/Kg is expected without any beneficiation.

This specification contains the criteria for the design and installation of Equipment and Material for the 2 X 500 to 600 MW Thermal Power Project and describes the basic concepts, basis and philosophies for the whole project.

The objectives of this document are to provide the following guidance.

- Technical Requirements of the project
- Project design data
- Construction data

In cases where discrepancies exist between the information contained in this specification and the Contractual Agreement, the Contractual Agreement will govern.

### 1.2 Project Description

Plant Name	2 X 500 to 600 MW Malwa Thermal Power Project
Client	MP Power Gen. Co. Ltd (MPPGCL)
Plant Location	Near village Purni / Dongalia of Harsaud Tahsil in Khandwa district, Madhya Pradesh

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This project is green field project, the proposed project for the Thermal Power station of 1000 to 1200 MW capacity at initial stage has been considered to be executed by installing 2 X 500 to 600 MW unit with provision for development of necessary infrastructure facilities and addition of another 2000 to 2400 MW capacity in future is also envisaged with the main Power Plant Project.

Based on configuration study, the following configuration is selected for the project:

- Two Steam Turbine Generators and Auxiliaries: 500 to 600 MW each
- Two steam Generators and Auxiliaries
- Two Electrostatic Precipitators

The system of measurements shall be Metric - Modified SI:

- 1.3 Applicable Government Acts, Local Authority Regulations. Codes and Standards

Any specifications and standards listed herein are indicative only and a full and complete listing of all specifications and standards shall be as mentioned in Design Basis.

Where no specific references are made EPC shall base this Project on the latest editions of the Codes & Standards.

## 2.0 CODES AND STANDARDS

- 2.1 Except where otherwise specified, all items under Contractor's scope shall comply with the appropriate Indian Codes & Standards or agreed internationally accepted codes & standards as listed below under clause no.2.6, each incorporating the latest revisions at the time of contract.

- 2.2 Where the Contractor proposes alternative codes or standards he shall include in his bid one copy (in English) of each standards to which materials offered shall comply. In such case, the adopted alternative standard shall be equivalent to or superior to the standards mentioned in the specification.

- 2.3 The Plant shall conform to various statutory regulations such as Indian Boiler Regulations, Indian Electricity Rules, Indian Explosive Act. Factories Act., Environment (Protection) Act etc. Whenever required, approval from statutory authorities for the plant supplied under the specification shall be responsibility of the Contractor.

- 2.4 In the event of any conflict between the codes and standards referred above,

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and the requirements of this specification, the requirements that are more stringent shall govern.

- 2.5 In case of any change of code, standards and regulations between the date of award of contract and the date the Contractor proceeds with manufacturing, the Owner shall have the option to incorporate the changed requirement. It shall be the responsibility of the Contractor to advise Owner of the resulting effect.
- 2.6 The indicative list of Codes and standards is furnished below for reference of the main plant package Contractor :
- a) International Organisation for Standardisation (ISO)
  - b) International Electro-technical Commission (IEC)
  - c) American Society of Mechanical Engineers (ASME).
  - d) American National Standards Institute (ANSI)
  - e) American Society for Testing and Material (ASTM)
  - f) American Institute of Steel Construction (AISC)
  - g) American Welding Society (AWS)
  - h) Architecture Institute of Japan (AIJ)
  - i) National Fire Protection Association (NFPA), USA
  - j) National Electrical Manufacturer's Association (NEMA), USA
  - k) Japanese Electro-technical Committee (JEC)
  - l) American Water Works Association (AWWA)
  - m) Indian Boiler Regulations (IBR)
  - n) Standards of the expansion joint manufacturers association (EJMA)
  - o) Hydraulic Institute Standards (HIS)
  - p) Heat Exchange Institute (HEI)
  - q) Tubular Exchange Manufacturer's Association (TEMA)
  - r) Tariff Advisory Committee (TAC) of India
  - s) Oil Industry Safety Directorate (OISD)
  - t) American Petroleum Institute (API)
  - u) Indian Standards (IS)
  - v) British Standards (BS).

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- w) Deutsche Industrie Normen (DIN)
- x) Heat Exchange Institute Standards for Steam Surface Condensers
- y) American Society for Heating Refrigeration and Air-conditioning Engineers (ASHRAE)
- z) Roads shall be as per Ministry of Surface Transport (MOST) specifications(Latest revision)
- IRC Publication: Handbook of Quality Control for Construction of Roads and Runways.
  - IRC Publication: Ministry of Surface Transport (Road Wing) Specification for Road and Bridge Works.

**NOTE** : The above list of codes and standards is indicative and for the guidance. Codes and standards indicated in the respective sections and data sheets shall also be referred for completeness. Contractor to indicate in his offers any additional list of codes and standards, which he deems necessary for the design of his equipment/system.

2.7 System of Measurement

SI system of measurement shall be followed, with the exception of piping / tubing sizes which shall be reported in inches. System of measurement for this project shall be SI.

Units	SI	Remark
Temperature	°C	
Pressure (gauge)	bar (g)	
Vacuum	bar (a)	
Volume	m <sup>3</sup>	
Length	m	
Fine Length	mm	
Pipe diameters, flanges, nozzles	Inch (Nominal)	
Mass or Weight	kg	
<b>Mass or volume flows</b>		
- Steam and two phase flow	kg/s and TPD	



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Units	SI	Remark
- Gas Flow	kg/s and TPD	
- Liquid Flow	kg/s and TPD	
- Equipment specification	kg/s and TPD	
<b>Concentration</b>		
- Liquid	Wt % or wppm	
- Gases	Mole % or mole ppm	
Velocity	m/s	
Energy	kJ	
Power	kW	
Work	kWh	
Heat capacity	kJ/kg °C	
Thermal conductivity	W/m °C	
Fouling factor	m <sup>2</sup> °C/W	
Heat transfer coefficient	W/ m <sup>2</sup> °C	
Enthalpy	kJ/kg	
Viscosity	cp	
Viscosity Feed / products	cst @ 40 °C	
Density	kg/ m <sup>3</sup>	

**3.0 MINIMUM DESIGN LIFE.**

The Minimum Design Life of the Plant shall be 30 years.

**4.0 PROJECT SITE INFORMATION:**

**4.1 Plant Location**

Malwa Thermal Power Station is bounded by villages Bhangwanpura, Bhurlai, Dharakwadi and Devla.. The site is bounded by villages Bhagwanpura, Bhurial, Dabri & Jalkuan. The geographic location of site is at a latitude of



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22°06'' and longitude of 76°23'08''. The average ground level of the site for main power block, after initial site grading is 282 mtrs. above MSL

- 4.2 The design of the System and system components for the proposed station would consider the following Meteorological Design Data:

Sl.No	Description	Parameters / Design Data
i)	Maximum Dry Bulb / design ambient temperature (for plant and Equipment)	47.2° C/ 50° C
ii)	Environment for Electrical Equipment	Hot, Humid and Dust laden
iii)	Seismic zone as per IS-1893	Zone-III
iv)	Basic. wind speed as per IS-875	39 m / sec
v)	Soil Bearing Capacity / Pile foundation design parameter	To be established by the Contractor
vi)	Cooling Water temperature to the condenser	33° C (max)
vii)	Instrument air / plant Air	Oil free (Inst. Air-Desiccant dried)
viii)	Power Supply to drives (3 Ph.50 Hz. DOL-start)	Up to 200 kW rating at 415 V. All motors above 200 kW will be supplied from 6.6 kV system.
ix)	Control Voltage to electrical equipment / to Instrumentation & control	At 220 V DC (unearthed) / 24 V DC

- 4.3 Rainfall

Design rainfall intensity shall be considered as 60 mm per hour.



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## 5.0 UTILITIES

### 5.1 WATER

5.1.1 In this Coal fired Thermal Power Station, water is used to meet the following requirements :

- Cooling water for steam condenser which act as a heat sink and other auxiliary cooling of turbine oil, bearings of generators, motors etc.
- For boiler make-up and other Process equipment.
- For miscellaneous services e.g. air conditioning, ventilation, ash handling, fire fighting dust extraction/suppression coal yard, horticulture etc.

The source of water for this project will be taken from the Indira Sagar Dam implemented by NVDA on river Narmada.

The expected Raw Water Analysis is as follows:

Sl. No	Contents	During Winter Season	During Summer Season	During Season	Rainy
Physical Examinations :					
1	pH	8.2 to 8.4	8.5	8.5	
2	Turbidity (Silica Scale) p.p.m	5 to 20	5 to 20	300 to 1000	
3	Colour (Hazen Scale)	Nil	Nil	Nil	
4	Colour (Threshold No)	Nil	Nil	(Pungent)	
5	Temperature Deg C	---	---	---	
Chemical Examinations					
1	Free CO <sub>2</sub>	---	---	---	
2	P-Alkalinity phenolphale in CaCO <sub>3</sub> ppm	2	2	10	



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3	M-Alkalinity phenolphale in CaCO <sub>3</sub> ppm	100	100	124
4	Hardness as CaCO <sub>3</sub> ppm	72	72	72
5	Calcium hardness, ppm	42	42	42
6	Magnesium hardness, ppm	30	30	30
7	Carbonate hardness, ppm	72	72	72
8	Non-carbonate hardness	Nil	Nil	Nil
9	Chloride as Cl.ppm	12	12	12
10	Sulphates as SO <sub>4</sub> ppm	40	40	40
11	Nitrites NO <sub>2</sub> ppm	Nil	Nil	Nil
12	Nitrates NO <sub>3</sub> ppm	Nil	Nil	Nil
13	Free Ammonia (N)	---	---	---
14	Alluminia Ammonia (N)	---	---	---
15	Absorbed in 3 hrs (Tidy's process)	---	---	---

## 5.2 COAL

5.2.1 The primary fuel for the steam generator shall be low grade coal. The coal is normally to be supplied from either Wardha Valley Coal Fields of Western Coal Fields Limited (WCL) or Collories of SECL. The likely range of coal quality parameters are indicated below.

The design coal for the purpose of guaranteed efficiency and auxiliary power consumption as well as worst coal and best coal analysis arrived at for this project will be of the following analysis.

### a) Proximate Analysis (% by weight) (As received basis)

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	<b>Design</b>	<b>Worst</b>	<b>Best</b>
Fixed Carbon	25.0	20.0	23.7
Volatile Matter	19.0	19.4	23.1
Ash	44.0	45.6	43.2
Moisture	12.0	15.0	10.0
Gross Calorific value	3500	3150	3700

**b)Ultimate Analysis (% by weight)**

	<b>Design</b>	<b>Worst</b>	<b>Best</b>
Carbon	35.38	31.50	37.11
Hydrogen	2.50	2.33	2.75
Sulphur	0.26	0.44	0.47
Oxygen (by diff.)	5.20	4.54	5.77
Nitrogen	0.66	0.59	0.70
Carbonates	--	--	--
Phosphorous	--	--	--
Ash	44.00	45.60	43.20
Moisture	12.00	15.00	10.00
Grindability Index (HGI)	50	47	55

	<b>Design</b>	<b>Worst</b>	<b>Best</b>
ii) a) Ash Fusion Temp. (IDT)	1250	1200	1569
b) Softening Temp.(Deg.C.)	1300	1480	1579
c) Hemispherical Temp.°C.	1370	1540	1602

5.2.2 Ash Characteristics

	<b>Design</b>	<b>Worst</b>	<b>Best</b>
Si O2	60.15	65.50	69.50
Al2 O3	27.44	24.30	24.80
Fe2 O3	5.60	2.72	3.33
Ti O2	1.53	1.47	1.37
P2 O3	0.53	--	--
MnO	--	--	--
CaO	1.43	0.48	0.71
MgO	0.97	0.42	0.43
Alkalies	1.99	1.46	1.65

**Note : All CVs are calculated values :**



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- 5.2.3 For the purpose of bid evaluation, maximum guaranteed efficiency shall be calculated on the basis of the following coal analysis, taking into account the deterioration in coal in actual mining.

Gross CV	3500 Kcal/Kg
Moisture	12 %
Hydrogen	2.5 %
Ash	44 %
Anticipated total moisture (as received coal)	15 %
HGI	50

Correction curves shall be supplied for the variation of the above parameters and other parameters to facilitate adjustment of Efficiency calculated when actual tests are done.

- 5.2.4 The steam generator and its auxiliaries shall be capable of giving the guaranteed maximum continuous output under the most adverse conditions satisfactorily when firing coal as per variations in the coal quality parameters given above. The steam generator and its auxiliaries shall also be capable for giving BMCR when firing worst coal with the following characteristics:

Maximum moisture	15 %
Maximum Ash	45.6 %
Maximum inert	61 %
Moisture + Ash	
Min. Calorific Value	3150 Kcal/Kg.(at 60% RH & 27° .C.)
HGI	47
IDT of coal Ash(oC.)	1200

- 5.2.5 The selection/sizing of equipment and auxiliaries for steam generator shall be made taking into consideration the most adverse conditions of coal quality given above as relevant/applicable to such selection.

- 5.2.6 The steam generator and its auxiliaries shall be designed for efficient and trouble free operation when firing the design, worst and best coals and the range of coal supplies having the characteristics given above and any of the coals characteristics in between these. The steam generator and its auxiliaries shall also be capable of giving BMCR rating, as specified and other operating capabilities matching the requirements of plant operating capabilities without any trouble and limitations, when firing the coals having the range of



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characteristics specified. The Contractors are advised to collect coal samples for independent analysis of coal combustion, slagging/fouling characteristics etc. to satisfy themselves so as to meet all specified requirements.

**5.3 FUEL OIL**

5.3.1 The fuel oils (HP/LSHS/Heavy Furnace oils), having characteristics as per relevant Indian Standards shall be used for start-up, coal flame stabilisation and low and load operation of the steam generator. In addition, the light diesel oil (LDO) firing facilities shall also be provided for cold start ups of the steam generator (s) LDO characteristics shall be as per relevant Indian Standard.

5.3.2 The design and construction of the steam generator and other equipment specified in this specification shall be suitable for firing all the fuel oils mentioned above for operation of the steam generator & firing any of the above fuels in any combination with coal.

**(A) Analysis of Heavy Fuel Oil :**

Sl.No	Description	HFO
1	Specification	Furnace Oil conforming to IS:1593 of 1971 - Heavy Grade
2	Average Gross Calorific Value	10,000 Kcal/Kg
3	Flash Point	66° C. Min. (PMCE)
4	Pour Point	50° C. max.
5	Kinematic Viscosity at 50°C	370 Centistokes
6	Specific Heat	0.5 Kcal/Kg/Deg.C. (Average)
7	Ash, % by weight	0.1 Max.
8	Sediment, % by weight	0.25 Max
9	Sulphur, % by weight	4.5 max.
10	Water content by volume	1.0
11	Acidity	Nil
12	Specific Gravity	0.95 to 0.96 average
13	Vanadium contents (ppm)	70 ( Typical)
14.	Sodium + Potassium (ppm)	40 ( Typical)

**(B) Analysis of heavy Petroleum Stock (HPS)**

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1	Calorific Value	Around 10,000 Kcal/Kg
2	Flash Point	66°C Minimum
3	Pour Point	72°C. max
4	Kinematic Viscosity at 50°C	500 Centistokes
5	Kinematic Viscosity at 100°C	50 Centistokes
6	Ash, % by weight	0.1 Max.
7	Sediment, % by weight	0.25 (Max.)
8	Sulphur, % by weight	4.5 (max.)
9	Water content % by volume	1.0 (Max.)
10	Acidity inorganic	Nil

**(C) Analysis for Low Sulphur Heavy Stock (LSHS) fuel Oil :**

Sl.No	Description	LSHS	
1.	Gross Calorific Value	Around 10,000 Kcal/Kg	
2.	Flash Point	75°C Min.	
3.	Pour Point	57°C. max	
4.	Total Sulphur, % by weight	1 (max.)	
5.	Ash, % by weight	0.05	
6.	Sediment, % by weight	0.05 (Typical)	
7.	Water content % by volume	1.0 (Max.)	
8.	Specific Gravity	0.865 Min	
9.	Specific heat	0.65 Kcal/Kg/Deg.C	
10.	Viscosity (max.)		
	Temperature (°C)	CST	Red Wood No.1
	38	-	--
	50	40	166
	60	26	112
	70	20	150 Max.
	80	13.5	63
	90	10.5	53
	99	8.5	47.5



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	100	--	49.5
	110	--	--



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**(D) Analysis for Light Diesel Oil (LDO) : As per IS:1460(latest)**

Sl.No	Description	LDO
1	Specification	IS -1460 ( latest revision)
2	Gross Calorific Value	10,000 Kcal/Kg
3	Flash Point (Pen sky-Martens closed)	66° C. Min.
4	Pour Point ( winter) Pour Point ( summer)	12° C. 18°C.
5	Viscosity at 38°C	15.7 Centi-stokes
6	Ash, % by weight	0.02 Max.
7	Sediment, % by weight	0.10 Max
8	Sulfur, % by weight	1.8 Max.
9	Water content by volume	0.25 Max.
10	Acidity ( inorganic)	Nil
11	Specific Gravity	0.85 at 15° C
12	Carbon Residue	1.5 % (Maximum)
13	Carbon strip corrosion for 3 hrs at 100° C	Not worse than No.-2
14	Total sediment – mg / 100 ml	Max – 1.0

The design and construction of the steam generator and other equipment specified in this specification shall be such as not to call for any other liquid or gaseous fuel than that mentioned above for purpose of operation of the steam generator at low load including initial ignition. High energy igniters shall be used for ignition of HFO/HPS/LSHS fuel oil directly.



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**TECHNICAL SPECIFICATION FOR EXCAVATION AND FILLING**

**END USER**

**MADHYA PRADESH POWER GENERATING  
COMPANY LIMITED**

**LTSL PROJECT No.**

**T 408000**

**LTSL DOC. No**

**MALWA-SP-C-001**

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**TECHNICAL SPECIFICATION  
FOR EXCAVATION AND FILLING**

**1.1.0 INTENT**

- i) This specification covers the technical requirements of excavation and filling for structures, buildings, pipes, foundations, trenches, pits, drains, channels, cable ducts, underground facilities & similar works. It also covers filling areas and plinths with selected materials, conveyance and disposal of surplus spoils and / or stacking them properly as directed by the Engineer.
- ii) This specification covers the technical requirements of CNS (Cohesive Non-Swelling) material, filling in and around structures, buildings, pipes, foundations, trenches, pits, drains, channels, cable ducts, underground facilities and similar works. It also covers filling areas and plinths with CNS materials, conveyance and disposal of surplus spoils and / or stacking them properly as directed by the Owner.
- iii) The Contractor shall be fully responsible for proper setting out of works, profiling in excavation, stacking of material. It shall be the responsibility of the Contractor to make adequate safety measures at the site. The Contractor shall carry out all works meant within the specification, even if not explicitly mentioned herein. All works shall be executed to the satisfaction of the Engineer.
- iv) The Contractor shall take all necessary precaution so as not to damage or endanger any property, structures, roads, installation or services in the vicinity of the area. It shall be the responsibility of the Contractor, to take all necessary measures to protect existing facilities, trees or any other structures within or adjacent to the works being carried out which are not to be disturbed. The Contractor shall provide and install suitable safeguards approved by the Engineer for this purpose.
- v) The Contractor shall make all necessary and adequate measure during the progress of work against soil erosion, water and environmental pollution. It shall be the responsibility of the Contractor to undertake any additional work necessary to achieve this objective at no additional cost to the Owner.
- vi) The Contractor shall take prior approval from the Engineer about his work plan and the procedure he intends to follow for the works covered under the scope of this specification and the schedule for carrying out temporary and permanent

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control works. However, the approval of such plans and procedures shall not relieve the Contractor of his responsibility for safe and sound work.

**1.2.0 GENERAL REQUIREMENTS**

- i) Prior to beginning excavation and filling work, a contract or permit shall be obtained from the Owner.
- ii) The Contractor shall make arrangements to perform surveying activities in locating co-ordinates and establishing reduced levels. The Owner shall furnish the Contractor with two reference grid lines and one Benchmark. The Contractor shall make necessary arrangement for all the survey instrument along with qualified surveyor to the satisfaction of the Engineer, so that work can be carried out accurately and according to the specification and drawings.
- iii) The Contractor shall furnish all skilled and unskilled labour, plant, tools, tackles, equipment, men, materials, required for complete execution of the work in accordance with the statutory labour regulation, drawings and as described herein and / or as directed by the Engineer.
- iv) The plot boundaries shall be marked using stakes or lath with coloured plastic flagging. The lath shall be placed at sufficient interval to enable work crews and the Owner to identify the boundaries of excavation / filling.
- v) The Contractor shall make all necessary and adequate measures to prevent water from the site of his operation from causing nuisance on or in any adjacent areas/sites and neighboring property. The Contractor shall construct wherever necessary temporary drainage or other siltation prevention structures to prevent surface water from running into the excavated areas during construction. It shall be responsibility of the Contractor to properly slope the surface of the ground to the satisfaction of the Engineer.
- vi) The materials obtained from within the plot area as a result of excavation or any previously unrecorded services or other objects discovered during excavation shall be notified to the Owner. Any material of archaeological importance or of value (in the opinion of the Engineer) discovered during excavation shall be stacked separately and in a regular manner at locations identified by the Engineer.
- vii) It shall be responsibility of the Contractor to locate existing utilities and services if any at the locations within the work premises by contacting local authorities. Any information available with the Owner shall be made available to the Contractor on request. The Contractor shall take every preventive measure,

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including provision of all necessary temporary supporting, bridging, and shoring and safety barriers, to protect these services and facilities from damage or interference during the execution of the works. The stability of existing above ground and under ground services shall be maintained during the work.

- viii) Excavation shall include removal of trees, including roots and organic remains, vegetation, grass, bushes, shrubs, plants, poles, fences, etc. that are in the area to be excavated as well as beyond the excavation line so as to ensure safety of the excavated side slopes, and of men and equipment operating in the area. Before start of work, joint measurements of ground level shall be taken after clearing all grass, vegetation etc.
- ix) Excavation shall include the removal of all materials required to execute the work, properly and shall be made with sufficient clearance as decided by the Engineer or defined by payment line to permit the placing and setting of forms, inspection and completion of all works to the satisfaction of the Engineer for which the excavation was done.
- x) The Contractor shall perform the work as per the drawings, issued to him and / or Contractor's drawings, which are approved by the Engineer and / or the Engineer's instruction.
- xi) All materials required for the work shall be of best commercial variety and approved by the Engineer. Borrow material required for filling shall be excavated from approved locations and levels and shall consist of material, free from roots, vegetation, decayed organic matter, harmful salts and chemicals, free from lumps and clods. If specified, clean graded sand, free from harmful and deleterious material from approved quarries, shall be used as fill material.
- xii) The Contractor shall carry out the proposed work in smooth cordial manner with Contractors of other on going works in the plant.
- xiii) Wherever reference is made to 'drawings' in this specification it shall mean the latest issue of the 'Released for Construction' drawings.

**1.3.0 CODES AND STANDARDS**

- i) All standards, specifications, acts, and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions.
- ii) In case of conflict between this specification and those (IS standards, codes etc.) referred to herein, the former shall prevail. In case any particular aspect of work is not covered specifically by this specification and IS Codes, any other standard practice as may be specified by the Engineer, shall be followed.

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iii) Some of the relevant Indian Standards, Acts and Codes referred are given below:

IS:383	Specification for coarse and fine aggregates from natural sources for concrete.
IS:1037	Code of practice for field control of moisture and compaction of soils for embankment and sub-grade.
IS:1200	Method of Measurement of building and civil engineering work earthwork (Part-I).
IS:2720	Methods of test for soils -Determination of water content etc. (Part-II, IV to VIII, XIV, XXI, XXIII, XXIV, XXVII to XXIX, XL)
IS:3764	Safety code for excavation work.
IS:4701	Code of practice for earthwork on canals.
IS:9758	Guide lines for Dewatering during construction.
IS:4081	Safety code for blasting and related drilling operations.
IS:6922	Criteria for safety and design of structures subject to underground blasts.

## **1.4.0 TECHNICAL REQUIREMENT- EXECUTION**

### **1.4.1 EXCAVATION & CLASSIFICATION**

The excavation shall be carried out as per the approved proposal. The work shall be carried out without endangering the safety of nearby structure and without causing hindrance to other activities in the area. As the excavation reaches the required dimensions, lines, levels and grades, the Engineer shall be notified, so as to avoid any over excavation. In certain cases, where deterioration of the ground, upheaval, slips, etc., are expected, the Engineer may order to suspend the work at any stage and instruct the Contractor to carry out the balance work later. No extra will be paid to the Contractor for such unavoidable temporary suspension of work.

For purposes of work to be executed in accordance with this specification, the following classification only, shall apply. In case of any dispute regarding

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classification of materials excavated / filled, the decision of the Engineer shall be final and binding on the Contractor.

**1.4.1.1** Soil / Rock shall be classified as follows;

A) Soil

Earth excavation shall consist of removal of all material encountered which can be excavated by pick axes or spades or earth moving equipment such as shovels, draglines, etc. and which are not classified under rock as defined in specification. Earth excavation shall include, but shall not be limited to, vegetation or organic soil, turf, sand, silt, mud, moorum, shingle, clay, gravel, loam, macadam, peat, shale, ash, marsh, bricks, tar/bitumen surfaces, lime concrete, stone/brick masonry etc. It shall also include embedded rock, boulders having maximum diameter in any one direction not exceeding 300 mm.

B) Soft Rock / Disintegrated / Weathered Rock (not requiring blasting, wedging or similar means)

This may be quarried or split with crow bars or pick axes such as lime stone, sand stone, hard laterite, hard conglomerate and unreinforced cement concrete below ground level. It shall also include rock, which is normally hard requiring blasting when dry, but can be excavated without blasting, wedging or similar means, when wet. Soft rock excavation shall consist of the excavation of boulders, having maximum diameter in any direction or more than 300 mm lying loose on the surface or embedded in soil, and all rock in ledges, and bedded / conglomerated deposits so firmly cemented that they cannot be removed by common earthmoving tools/equipment.

C) Hard Rock

Hard rock (requiring blasting) - Any rock or boulder for the excavation of which blasting is required such as quartzite stone, granite, basalt, reinforced cement concrete (reinforcement to be cut through but not separated from concrete) below ground level etc.

Hard rock (blasting prohibited) - This shall cover any Hard rock requiring blasting as described under 4.1.2 above but where blasting is prohibited for any reason and excavation has to be carried out by chiseling, wedging or any other approved method.

In case of any dispute regarding classification, the decision of the Engineer shall be final.

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**1.4.2 EXCAVATION IN SOIL**

- i) Sides and bottoms of excavation shall be cut sharp and true to line and level. Undercutting shall not be permitted. When machines are used for excavation, the last 300mm before reaching the required level shall be excavated manually. Suitability of strata (at the bottom of excavations) for laying the foundation thereon shall be determined by the Engineer.
- ii) Excavation for foundations shall be to the bottom of lean concrete and as shown on drawings or as directed by the Engineer. The bottom of all excavations shall be trimmed to required levels and when excavation is carried below such levels, by error, it shall be brought back to specified level by filling with concrete of nominal mix 1:4:8 (cement: coarse sand: 40mm down aggregates) as directed by the Engineer at the Contractor's cost.
- iii) The Contractor shall ascertain for himself the nature of materials to be excavated and the difficulties, if any, likely to be encountered in executing this work. Cofferdams, sheeting, shoring, bracing, maintaining suitable slopes, draining etc. shall be provided and installed by the Contractor at no extra cost, unless mentioned in the Schedule of Items, to the satisfaction of the Engineer.
- iv) All excavation for installation of underground facilities, such as piping, cable duct, sewer lines, drain lines, etc. shall be open cuts. For deep and huge excavations and in other excavations, if required by the Engineer, the Contractor shall submit an "Excavation Scheme" for Engineer's approval showing the methodology to be adopted for excavation in order to maintain the stability of side slopes, means for ensuring safety of existing facilities nearby, dewatering as described in specification. However, the Contractor shall be fully responsible for the scheme irrespective of any approvals granted. Benching shall be provided for deeper excavation wherever required.
- v) When excavation requires bracing, sheeting or shoring etc., the Contractor shall submit drawings to the Engineer, showing arrangements and details of proposal installation. The Contractor shall also furnish all supporting calculations as called for and shall not proceed until he has received written approval from the Engineer. However, the responsibility for adequacy of such bracing, sheeting, shoring etc., will rest with the Contractor, irrespective of any approval of the Engineer.
- vi) The Contractor shall have to constantly pump out any water collected in excavated pits and other areas due to rain water, seepage, springs etc. and maintain dry working conditions at all times until the excavation, placement of

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reinforcement, shuttering, concreting, back filling is completed. For the purpose of keeping the area dry through dewatering process, additional sumps as required as per site condition are to be made/excavated by the Contractor. The Contractor shall remove all slush/muck from the excavated areas to keep the work area dry. Sludge pumps, if required, shall be employed by the Contractor for this purpose.

vii) The Contractor shall remove all materials arising from excavations from the vicinity of the work either for direct filling, stacking and subsequent filling or for ultimate disposal as directed by the Engineer. In no case, shall the excavated soil be stacked within a distance of 3.0m from the edge of excavation or one-third the depth of excavation whichever is more. Material to be used for filling shall be kept separately.

viii) Excavated material shall be used for fill unless it is classified as unsatisfactory.

#### **1.4.3 EXCAVATION IN DISINTEGRATED / WEATHERED ROCK**

i) All clauses of excavation in soil as mentioned above shall be applicable to excavation in disintegrated / weathered rock also. In case of any discrepancy between the above mentioned clause and those specified in this clause then the later shall govern.

ii) The Contractor shall arrange for excavating such rock by profusely wetting it. If required, light blasting may be resorted to for loosening the materials at Contractor's cost, but this will not entitle the material to be classified as Hard rock.

iii) In case of overbreaks in rock excavation, the excavated level shall be brought to the level shown on drawings with plain cement concrete of nominal mix 1:4:8 as described in relevant clauses for excavation in soil as mentioned above.

#### **1.4.4 EXCAVATION IN HARD ROCK**

All clauses excavation in soil shall be applicable to excavation in rock also. In case of any discrepancy between the above mentioned clause and those specified in this clause then the later shall govern.

In case of overbreaks in rock excavation, the excavated level shall be brought to the level shown on drawings with approved fill material, compacted.

##### **1.4.4.1 Excavation by Blasting :**

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- i) Blasting shall be carried out only with the written permission of the Engineer. All the statutory laws, (Explosives Act etc.) rule, regulations, Indian Standards, etc. pertaining to the acquisition, transport, storage, handling and use of explosives, etc. shall be strictly followed.
- ii) The Contractor shall obtain Licenses from Competent Authorities for undertaking blasting work as well as for procuring, transporting to site and storing the explosives as per Explosives Act. The Contractor shall be responsible for the safe transport, use, custody and proper accounting of the explosive materials.
- iii) The Contractor may adopt any method of blasting as permitted according to explosives act/rule consistent with the safety and job requirements (after approval from the Engineer) and so as not to injure men or damage materials/structures during blasting operations.
- iv) The magazine for the storage of explosives shall be built by the Contractor to the designs and specifications of the Explosives Department concerned and located at the approved site. No unauthorized person shall be admitted into the magazine which, when not in use, shall be kept securely locked. No matches or inflammable material shall be allowed within 100 m of the magazine. The magazine shall have an effective lightning conductor and the following shall be hung in the lobby of the magazine.
  - A copy of the relevant rules regarding safe storage, both in English and in the language(s) with which the workers concerned is familiar.
  - A statement of up to date stock in the magazine
  - A certificate showing the last date of testing of the lightning conductor.
  - A notice stating that smoking is strictly prohibited
- v) The Contractor shall also observe any specific instructions given by the Engineers. The Contractor shall be responsible and liable for damage to property and any accident which may occur to workmen or to the storage, transportation, handling or use of explosive and the blasting operations. The Engineer or his authorised representative shall frequently check the Contractor's compliance with these precautions and the manner of storing and accounting of explosives. The Contractor shall provide necessary facilities for such inspection.
- vi) All materials, tools and equipment used for blasting operations shall be of approved make and type. In special cases, the Engineer may specify the type of

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explosives to be allowed. The fuse to be used in wet locations shall be sufficiently water resistant so as to be unaffected when immersed in water for 30 minutes. The rate of burning of the fuse shall be uniform and precisely known to permit evaluation of the distance to which the fire should move before explosion takes place.

- vii) The blasting powder, explosives, detonators, fuses etc. shall be fresh and not damaged due to dampness or any other cause. Explosives shall be kept dry and shall not be exposed to direct rays of the sun or be stored in the vicinity of fire, stoves, steam pipes or heated metal etc. They shall be inspected before use and damaged articles shall be discharged totally and removed from site immediately.

#### **1.4.4.2 Blasting Operations**

- i) The blasting operations shall remain in the charge of a responsible, competent, authorised and experienced supervisor (called Man-in-Charge) and workmen who are thoroughly acquainted with the details of handling explosives and blasting operations and with the rules governing such work.
- ii) All rules under the Explosives Act and other local rules in force shall be fully observed. All blasting works shall be done in accordance with the stipulations contained in IS 4081. Blasting shall only be carried out at certain specified times preferably during the mid-day lunch time or at the days work closing hours as directed in writing by the Engineer. The hours when blasting will be done, shall be made known to people in the vicinity. All the charges shall be prepared by the Man-in-Charge (as described above) only. Proper precautions for safety of persons and property shall be taken.
- iii) Prior to blasting, red danger flags shall be displayed prominently around the area to be blasted and shall be kept in position until blasting work is completed. All people, except those who actually light the fuses, shall be prohibited from entering this area. The flags shall be planted 200 m from the blasting site and all persons including workmen shall be evacuated from the flagged area atleast 10 minutes before the firing. A warning whistle shall be sounded for this purpose.
- iv) Controlled blasting shall be carried out within 200 m of an existing structure unless otherwise permitted by the Engineer in writing. Where (generally within plant area) controlled blasting is to be carried out in the proximity of other structures, then sand bags and/or earth bags, etc. shall be used on top of the blast holes to prevent the rock fragments from causing damage to adjacent structures and property. At all stages of blasting operations, precautions shall be taken to preserve the rock in the soundest possible condition below and beyond the lines specified for the excavation. The quantity and strength of explosives used shall

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be such as will neither damage nor crack the rock outside the limits of excavations. Any method of blasting which leads to overshooting shall be discontinued.

- v) No explosive shall be brought near the work in excess of the quantity required for a particular amount of firing to be done and surplus left after filling holes shall be removed to the magazine. A careful and day to day account of the explosives shall be maintained by the Contractor in an approved manner and in an identified register; which shall be open to inspection by the Engineer at all times.
- vi) At a time not more than ten such charges shall be prepared and fired. The Man-in-Charge shall blow the whistle in a recognized manner for cautioning the people. The number of blasts to be fired and actual number of shots heard shall be compared and the person responsible shall satisfy himself by examination that all blasts have exploded before any person working in the area is permitted to re-approach the work site. Sufficient time shall be allowed to account for delayed blasts. The Man-in-Charge shall inspect all the charges before lighting and determine the missed charge. The withdrawal of the unexploded charge shall not be permitted under any circumstances. After tamping, the unexploded charge shall be flooded with water and the hole marked in a distinguishable manner. Another hole shall be jumped at a distance of 450 mm from the old hole and fired in the usual way. This process shall be continued till the original blast is exploded. The Man-in-Charge shall at once report to the Contractor's office and the Engineer, all cases of misfire, the cause for the same and what steps were taken in connection therewith.
- vii) If a misfire is found to be due to defective materials, the whole quantity in the box, from which the defective materials was taken, must be sent to the Authority directed by the Engineer for inspection to ascertain whether any of the remaining materials in the box are also defective.

#### **1.4.4.3 Chiseling / Wedging**

Where blasting is prohibited for any reason or it is not practicable in opinion of the Engineer, then the excavation shall be carried out by chiseling, wedging or any other approved method. The decision of the Engineer in this regard shall be final and binding on the Contractor.

#### **1.4.4.4 Line Drilling and Preshearing**

- i) This shall be carried out only if so specified or called for by the Engineer. It is generally called for only when excavation in rock has to be carried out to exact

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lines and levels and when absolutely no over-excavation is permissible. It may also be required when rock excavation has to be carried out in close proximity of existing structures / equipment.

- ii) The number, size and location of holes shall be carefully worked out by the Contractor and shall be subject to the approval of the Engineer. Line drilled holes shall generally be 48 mm diameter and, if so directed, interior blasting holes shall also be made. The Contractor shall carry out tests to determine the amount of explosives required ensuring an even break at the line drilled holes. After the interior holes are blasted any irregularities in the vertical drilled line face shall be removed and trimmed by wedging, splitting, chiseling and barring.

#### **1.4.5 DEWATERING & EXCAVATION BELOW GROUND WATER TABLE**

- i) All excavations shall be kept free of water and slush. Grading in the vicinity of excavations shall be controlled to prevent surface water running into excavated areas. The Contractor shall remove by pumping or other means approved by the Engineer any water inclusive of rainwater and subsoil water accumulated in excavation and keeps the excavation area dewatered until excavation, concreting, curing and all other operation included in the scope of work, which require dry condition in the area are completed. Method of pumping shall be approved by the Engineer but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing in due to differential head of water during pumping.
- ii) Wherever ground water table is met with during excavation, the Contractor shall immediately report this fact to the Engineer who shall arrange to record the exact level of the water table before start of dewatering operation. The decision of the Engineer regarding ground water level shall be final and payable provided the Contractor has made arrangement for its dewatering. For this purpose, Contractor shall submit de-watering scheme to the Engineer before starting the excavation.
- iii) In case of ground water table is met with during excavation and approved by the Engineer, the Contractor shall dewater and maintain dry working conditions by maintaining the water table below the bottom of the excavation level by well-point dewatering or deep well dewatering or any other method approved by the Engineer. He shall continue doing so till excavation and all other operations included in the scope of work, which require dry condition in the area are completed.

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**1.4.6 LIFT**

The Contractor is required to excavate upto any depth as per requirement or as directed by the Engineer. Lifting of excavated materials shall be done either by manual or mechanical or both means if called for by the Engineer.

**1.4.7 CARRIAGE OF EXCAVATED MATERIALS**

- i) All suitable excavated material shall be directly utilized for filling purposes. In case the excavated materials are to be used for future filling purposes or found unsuitable for filling, they shall be stacked / stockpiled / disposed as directed by the Engineer. The carriage of excavated materials shall be done by the methods mentioned below:
- ii) The excavated materials shall be carried beyond the working area but upto 500 m manually or by mechanical means as directed by the Engineer.
- iii) For carriage exceeding 500 m and upto 2000m, the Contractor shall transport the excavated materials by mechanical means only and as directed by the Engineer. The Contractor shall arrange for temporary access roads for this purpose. Providing and maintaining of the access roads shall be the responsibility of the Contractor.
- iv) Some excavated materials required for filling purposes, may have to be carried upto a lead of 500 m and stacked as per instructions of the Engineer. Excavated materials carried beyond 500 m shall be for direct filling or for disposal purpose. Double handling of materials shall be avoided as far as possible. However, depending on site conditions, excavated materials carried beyond a lead of 500 m may also be required to be brought back for filling purpose.

**1.4.8 STOCKPILE AREA**

**1.4.8.1 Stockpile of Excavated Material**

- i) Stockpiling of excavated material suitable for filling purposes shall be done at the location as directed by the Owner / Engineer at site.
- ii) The stockpile area shall be sloped to drain properly and provided with devices to control erosion.
- iii) Stockpile of Rocks shall be done separately.

**1.4.9 Disposal of Excess Satisfactory Excavated Material**

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Excess excavated material, which is satisfactory for use as fill material, shall be used for other fills or be placed in a designated onsite stockpile area. Material may be removed from the stockpile area at a later date and utilized / disposed off as directed by the Engineer.

**1.4.10 Disposal of Unsatisfactory Material**

Excavated material, which is unsatisfactory for use as fill, shall be disposed of in an offsite or in an onsite disposal area as directed by the Owner / Engineer at site. Unsatisfactory material shall not be mixed with satisfactory material.

The disposal area shall be sloped to drain properly and control erosion and seeded.

**1.4.11 Ground Improvement Work**

If the existing engineering properties of the ground results in liquefaction, unacceptable total and/or differential settlement or bearing capacity failure, the Contractor shall carry out ground improvement work as per the recommendation in the soil investigation report, the requirement of the Owner and as directed by the Engineer.

Ground improvement techniques shall be covered separately, if required, and relevant Indian Standard Codes shall also be referred.

**1.4.12 FILLING**

**1.4.12.1 Materials**

- i) The material used for filling shall consist of material approved by the Engineer and obtained directly from nearby areas where excavation work is in progress or from temporary stacks of excavated spoils or from borrow pits from selected areas designated by the Engineer. The material shall be free from lumps and clods, roots and vegetation, harmful salts and chemicals, organic materials etc.
- ii) Materials, when used for filling purposes, shall be obtained from the excavated materials consisting of soil, stone, sand or other inorganic materials and they shall be clean and free from shingle, organic, large roots and excessive amount of sod, lumps, concrete or any other foreign substances which could harm or impair the strength of the substructure in any manner. All clods shall be suitably broken to small pieces. When the materials are mostly rock boulders, the same shall be stacked properly at the designated place as directed by the Engineer.

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Sand used for filling shall be clean, medium grained and free from impurities. Fines less than 75 microns shall not be more than 20% in any case and the materials to be used for filling purposes shall have the prior written approval of the Engineer.

- iii) Borrow materials, when used, shall be obtained from approved quarries and shall conform to the specification mentioned elsewhere. Acceptable granular materials are soils, which are classified as coarse-grained soils in the Indian Standard Soil Classification System, IS: 1498 - 1970. Classifications are GW, GP, GM, GC, SW, SP, SM or SC, or combinations of these such as SP-SC.
- iv) Cohesive material is suitable for use as Fill if it contains not more than 1 percent organic or other deleterious material, has a liquid limit of less than 40 and a plasticity index of less than 25. Acceptable cohesive materials are soils which are classified as fine-grained soils in the Indian Standard Soil Classification System, IS: 1498-1970. Classification is CL.
- v) Soil-rock mixtures are acceptable for use as fill if they contain a sufficient soil matrix to prevent nesting of larger pieces and the material contains less than one percent organic or other deleterious material.
- vi) It is intended to use the excavated earth from the site for filling provided the material conforms to the soil / soil-rock mixture specification as stipulated above and approved by the Engineer. If excavated materials are to be used for filling purposes, Contractor shall select the materials from the excavation / stockpile, test, load and transport this material and execute the filling. This shall include excavation of earth which may become hard due to laying in stockyard for long period of time. However this shall not be measured under excavation.
- vii) In case the materials have to be brought from pits/quarries, then it shall be the Contractor's responsibility for identification of such quarry, areas, obtaining approval for their use from concerned authorities, excavation/ quarrying, loading and carriage of such material, unloading and filling at such locations. The Contractor shall pay any fees, royalties etc. that may have to be paid for utilization of borrows areas.

**1.4.13 CNS (Cohesive Non-Swelling) Material**

The CNS material to be used for filling shall meet either 'a' or 'b' of the following criteria.

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<b>a)</b>	<b>i) Grain Size Analysis</b>	
	Clay	15 - 25 %
	Silt	35 - 50 %
	Sand	30 - 40 %
	Gravel	Less than 10 %
	<b>ii) Consistency Limits</b>	
	Liquid Limit	30 - 50 %
	Plastic Limit	20 - 25 %
	Plasticity Index	10 - 25 %
	Shrinkage Limit	15 % and above
	<b>iii) Swelling Pressure</b>	
	<ul style="list-style-type: none"><li>• Swelling pressure when compacted to maximum Less than dry density corresponding to standard proctor 0.1 kg/cm<sup>2</sup> compaction with zero initial compaction moisture constant, for no volume change condition</li><li>• Swelling pressure when compacted to maximum Less than dry density corresponding to standard proctor 0.05 kg/cm<sup>2</sup> compaction and initial compaction moisture corresponding to optimum moisture content for no volume condition</li></ul>	
<b>b)</b>	CNS material with optimum percentage of clay upto 70 % shall be mixed with sand (30 %) and lime (1- 2 %) to meet consistency limits and swelling pressure as specified above.	

**1.4.13.1 Material unsatisfactory for use as fill are as follows;**

- Soils classified as silt or organic soils in the Indian Standard Soil Classification System, IS:1498-1970. Classifications are ML, MH, PT, OL and OH.
- Soil classified as high liquid clay soils in Indian Standard Soil Classification System, IS:1498-1970. Classification is CH.
- Rock material without a soil matrix in which nesting of rocks could occur.
- Any material, which is frozen, contains an excessive amount of organic material or trash or contains large rocks, shall be considered unsatisfactory for use as fill.
- Top soils which are friable sandy-loam suitable to sustain the growth of vegetation

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- Restrictions on the use of poorly graded sand (SP) or silty sand (SM) material are as follows:
- No granular material with a silt content of greater than 15 percent shall be used for Fill.

#### **1.4.13.2 Filling Procedure**

- i) After completion of foundation, footings, walls and other construction below the elevation of the final grades, and prior to filling, all temporary shoring, timber, etc. shall be sequentially removed and the excavation cleaned of all trash, debris, and perishable materials. Filling shall begin only with the written approval of the Engineer. Also, areas identified for filling shall be cleared of all soft pockets, vegetation, bushes, slush etc. In case of plinth and similar filling, the ground shall be dressed and consolidated by ramming and light rolling.
- ii) Fill materials shall not be dropped directly upon or against any structure or facility where there is danger of displacement or damage. Filling shall be started after the concrete/masonry has fully set and shall be carried out in such a manner so as not to cause any undue lateral thrust on any part of the structure.
- iii) All space between foundation (concrete or masonry) and the sides of excavation shall be filled to the original surface after making allowance for settlement. Fill shall be placed in horizontal layers not exceeding 300mm loose thickness. Each layer shall be watered and compacted with proper moisture content and with such equipment as may be required to obtain a compaction/density as specified. Trucks or heavy equipment for depositing or compacting fill shall not be used within 1.5 meters of building walls, piers, or other facilities which may be damaged by their weight or operation. The methods of compaction shall be subject to the approval of the Engineer. Pushing of earth for filling shall not be adopted under any circumstances.
- iv) Fill adjacent to pipes shall be free of stones, concrete, etc. and shall be hand placed and compacted uniformly on both sides of the pipe and where practicable up to a minimum depth of 300mm over the top of pipes. While tamping around the pipes, care shall be taken to avoid unequal pressure.
- v) Filling shall be accurately finished to line, slope, cross section and grade as per requirement. Finished surface shall be free of irregularities and depressions and shall be within  $\pm 20$ mm of the specified level.

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- vi) Where filling with stone from excavated materials is specified, it shall be from broken pieces of boulders. At first, a 75mm thick cushion of selected earth shall be laid over which the 200mm thick graded stones shall be laid in loose layers of 200mm and then the interstices filled with available earth/ moorum. Each layer shall be watered and compacted to the specified density before the next layer is laid. However, no cushion shall be required where filling is over non-rocky surface.
- vii) Where filling with 65mm down graded stone obtained from excavated materials/borrow areas/quarries is specified, it shall be selected stone laid over an initial 50mm thick cushion layer of selected earth and then stone laid in 200mm loose thick layers, interstices filled with properly graded fine material consisting of selected earth brought from borrow areas. Each layer shall be watered and compacted to the specified density before the next layer is laid. However, no cushion shall be required where filling is over non-rocky surface.
- viii) Where clean stone fill is specified, it shall consist of clean selected stone metal of 40mm nominal size. It shall be laid in layers not exceeding 150mm (loose) and lightly tamped before the next layer is laid. No compaction shall be required for this type of stone filling. Unless otherwise mentioned in the drawings or schedule of item.

**1.4.14 Compaction**

- i) Where compaction to 85% Standard Proctor Density is called for, such compaction shall be by mechanical means but the Contractor may be permitted to adopt manual means only if the Engineer finds that the desired compaction is achievable in the field.
- ii) Where compaction to 85% or more of Standard Proctor Density is called for, it shall be by mechanical means only. Where access is possible, compaction shall be by 12 Ton rollers smooth wheeled, sheep foot or wobbly wheeled as directed by the Engineer. A smaller weight roller may be permitted by the Engineer in special cases, but in any case not less than 10 passes of the roller will be accepted for each layer. Each layer shall be wetted or the material dried by aeration to moisture content of 3-5% above the Optimum Moisture Content, to be determined by the Contractor. Each layer shall be watered, rammed and compacted to the density as specified.
- iii) For compacting each sand layer, water shall be sprayed over it to flood it and it shall be kept flooded for 24 hours to ensure maximum compaction. Vibro-compactors shall also be used if necessary to obtain the required degree of compaction. Any temporary works required to contain sand under flooded

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condition shall also be undertaken. The surface of the consolidated sand shall be dressed to required levels or slope.

- iv) When soils are used that develop a densely packed surface as a result of spreading or compaction, the surface of each layer of fill shall be sufficiently roughened after compaction to ensure bond of the succeeding layer.
- v) After the compacted fill has reached the desired level, the surface shall be flooded with water for 24 hours, allowed to dry and then rammed and consolidated to avoid any settlement, at a later date. The compacted surface shall be properly shaped, trimmed and consolidated to an even gradient or level. All soft spots shall be excavated, filled and consolidated.
- vi) The degree of compaction of compacted fill in place will be subject to tests to be conducted by the Contractor and witnessed by the Engineer as the work progresses. The Contractor shall provide all the necessary facilities to make such tests. Each layer of compaction fill shall be tested before proceeding with the next layer. It shall be the responsibility of the Contractor to conduct tests to ascertain the degree of compaction of fill material in place. At the time of conducting test it shall be mandatory on the part of the Contractor to inform the Engineer. It is the Contractor's responsibility to request inspection prior to proceeding with further work.
- vii) If any test indicates that the compaction achieved is less than the specified degree of compaction, the Engineer may advise all fill placed subsequent to the last successful test to be removed and recompacted by the Contractor. Compaction procedure shall be amended as necessary to obtain satisfactory results.
- viii) When the Engineer specifies semi-compacted fill (area filling), the Contractor shall fill up such areas with available earth from stockpiles or borrow pits or directly from excavation without special compaction except that obtained by moving trucks, etc.

#### **1.4.15 TIMBER SHORING**

Timber Shoring made out of approved quality of timber shall be 'close' or 'open' type, depending on the nature of soil and the depth of pit of trench and the type of timbering shall be determined by the Engineer. It shall be the responsibility of the Contractor to take all necessary steps to prevent the sides of trenches and pits from collapsing.

##### **1.4.15.1 Close Timbering**

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- i) Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called 'polling boards'. These shall be of minimum 250x40 mm sections as directed by the Engineer. The boards shall generally be placed in position vertically in pairs, one board on each side of cutting, and shall be kept apart by horizontal walers of strong wood at maximum 1.2 metres spacing, cross strutted with ballies or as directed by the Engineer. The length of the balli struts shall depend on the width of the trench or pit.
- ii) In case where the soil is very soft and loose, the boards shall be placed horizontally against the sides of the excavation and supported by vertical walers, which shall be strutted to similar timber pieces on the opposite face of the trench or pit. The lowest board supporting the sides of the trench or pit shall remain exposed so that the vertical side of the trench or pit is exposed, and the earth is not liable to slip out.
- iii) The withdrawal of the timber shall be done very carefully to prevent the collapse of the pit of trench. It shall be started at one end and proceeded systematically to the other end. Concrete or masonry shall not be damaged during the removal of the timber. No claim shall be entertained for any timber which cannot be withdrawn and is lost or buried.

#### **1.4.15.2 Open Timbering**

In the case of open timbering, the entire surface of the side of trench pit is not required to be covered. The vertical board of minimum 250 mm width and minimum 40 mm depth shall be spaced sufficiently apart to leave unsupported strips of maximum 300 mm average width. The detailed arrangement, sizes of the timber and the distances apart shall be subject to the approval of the Engineer. In all other respects, specification for close timbering shall apply to open timbering.

#### **1.4.15.3 Treatment of Slips**

The Contractor shall take all precaution to avoid high surcharges and provide proper surface drainage to prevent flow of water over the side. These precautions along with proper slopes, berms, shoring and control of ground water should cause no slips to occur. Slips caused due to negligence of the Contractor will be cleared and back-filled later by him at his own expenses.

### **1.5.0 SAMPLING TESTING AND QUALITY CONTROL**

#### **1.5.1 General**

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- i) The Contractor shall examine the areas and conditions under which earthwork is to be done and notify the Owner in writing, about the conditions, detrimental to proper and timely completion of the Work.
- ii) The Contractor shall carry out all sampling and testing as per Table-1 and in accordance with the relevant Indian Standards. Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice in concurrence of the Engineer. Tests shall be done in the field and at a laboratory approved by the Engineer and the Contractor shall submit to the Engineer, the test results in triplicate within three days after completion of a test.
- iii) Material, placing procedures and installations and test conducted by the Contractor are subject to inspection. Such inspections and tests shall not relieve Contractor of responsibility for providing material and placement in compliance with this specification. The Owner reserves the right, at any time before final acceptance, to reject material not complying with the specified requirements.
- iv) The Contractor shall correct all deficiencies in earthwork which inspections and laboratory and field tests have indicated are not in compliance with this specification. The Contractor shall perform additional tests, at his expense, as may be necessary to reconfirm any noncompliance of the original work and as may be necessary to show compliance of corrected work.
- v) The Contractor shall promptly correct errors or flaws in the work or material identified during construction and which prevent proper installation. The Contractor shall make immediate substitution of the noncomplying material or shall make field changes to make the noncomplying material acceptable. The correction or substitution shall be performed at no cost to the Owner.

### 1.5.2 Quality Assurance Program

- i) The Contractor shall submit and finalize a detailed Field Quality Assurance (FQA) Program, within 30 days, from the date of award of the Contract according to the requirements of the specification. This shall include setting up of a testing laboratory, arrangement of testing apparatus/equipment, deployment of qualified/ experienced manpower, preparation of format for record, Field Quality Plan, etc. On finalising field quality plan, the Contractor shall identify hold points beyond which work shall not proceed without written approval from the Engineer.
- ii) Frequencies of sampling and testing including the methods for conducting the tests are given in Table-1. The testing frequencies set forth are the desirable

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minimum. Contractor shall perform additional tests as directed by the Engineer to satisfy him that the materials and works comply with the specifications.

### 1.5.3 Acceptance Criteria

Following Acceptance Criteria shall be followed:

- i) All individual samples collected and tested should pass without any deviation when only one set of sample is tested.
- ii) For re-test of any sample, two additional samples shall be collected and tested, and both should pass without any deviation.
- iii) Where a large number of samples are tested for a particular test, then 9 samples out of every 10 consecutive samples tested shall meet the specification requirement.
- iv) Tolerance on finished levels for all cutting and filling areas at approved interval shall be 20 mm.

**TABLE -1**

### **FREQUENCY OF SAMPLING AND TESTING**

<b>SR. NO.</b>	<b>Nature of Test/ Characteristic</b>	<b>Method of Test</b>	<b>No. of Samples &amp; Frequency of Test</b>	<b>Results</b>
<b>I.</b>	<b>Suitability of Fill Materials</b>			
	c) Grain size Analysis	IS:2720 (Part IV)	One in every 2000 Cu.m. for each type and each source of fill material	Test for soil and sand
	d) Liquid limit and Plastic Limit	IS:2720 (Part V)	Subjected to a minimum of two samples.	Test for soil
	e) Shrinkage Limit	IS:2720 (Part VI)	One in every 5000 Cu.m. for each type and each source of fill materials.	The frequency of Test shall be increased depending on the type of soil.

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SR. NO.	Nature of Test/ Characteristic	Method of Test	No. of Samples & Frequency of Test	Results
	f) Free Swell Index	IS:2720 (Part XL)		
	<b>Chemical Analysis</b>	IS:2720		
	a) Organic matter	Part XXII	One in every 5000 Cu.m.	Test for sand and soil.
	b) Calcium carbonate	Part XXIII	for each type and each	
	c) pH	Part XXVI	Sources of fill materials.	
	d) Total soluble sulphate	Part XXVII		
<b>II.</b>	<b>Standard Proctor Test</b>	IS:2720 (Part VII)	One in every 2000 Cu.m. for each type and each source of fill materials.	Test for soil for determining optimum moisture content, Dry density etc.
<b>III.</b>	<b>Moisture content of Fill before compaction.</b>	IS:2720 (Part II)	-do-	Test for soil
<b>IV.</b>	<b>Degree of compaction of Fill</b>		For area filling, one test for every 1000 Sq.m. for each compacted layer.	Test for soil
	a) Dry density by core cutter method Or Dry density in place by sand displacement method.	IS:2720 (Part XXIX)	For area filling, one test for every 1000 Sq.m. area for each compacted layer.	
	b) Relative density (Density Index)	IS:2720 (Part XIV)	-do- i) & ii)	Test for sand
	c) Dry Density by Proctor needle penetration	Standard Practice	Random checks to be carried out for each compacted layer in addition to tests mentioned under IV (a) above.	Test for sand

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Properties, Storage and Handling of  
Common Building Materials

Doc No : MALWA-SP-C-002

MP Power Gen. Co. Ltd.

For Bid

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**TECHNICAL SPECIFICATION FOR PROPERTIES, STORAGE AND HANDLING  
OF COMMON BUILDING MATERIALS**

**END USER**

**MADHYA PRADESH POWER GENERATING  
COMPANY LIMITED**

**LTSL PROJECT No.**

**T 408000**

**LTSL DOC. No**

**MALWA-SP-C-002**

**REVISION CERTIFICATION**

REV NO.	DATE OF ISSUE	PREPARED					REVIEWED					APPROVED
		MECHANICAL	ELECTRICAL	CIVIL	INSTRUMENTATION	PROCESS	MECHANICAL	ELECTRICAL	CIVIL	INSTRUMENTATION	PROCESS	
P0	31/7/06											
A	15/9/06											
B	30/4/07											

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**TECHNICAL SPECIFICATION  
FOR PROPERTIES, STORAGE AND HANDLING  
OF COMMON BUILDING MATERIALS**

**1.1.0 INTENT**

- i) The intent of this specification is to specify the properties, storage and handling of common building materials, namely, coarse aggregates, cement, lime, water, sand, masonry units, reinforcement and structural steel.
- ii) Properties of the materials in general have been discussed in this specification. Specific requirements of the materials have been stipulated separately under specification for relevant items of work.

**1.2.0 GENERAL REQUIREMENTS**

- i) The work shall include, providing all necessary plants and equipment, adequate engineering supervision and technical personnel, skilled / unskilled labour etc. as required to carry out the entire work as directed by the Owner to his complete satisfaction.
- ii) All materials proposed for use in the work shall conform to the requirements laid down in this specification and also subject to the approval of the Owner. After specific materials have been approved / accepted, the source of supply of such materials shall not be changed without prior approval of the Owner. Approval of any material by the Owner, shall not relieve the Contractor of his responsibility for the requisite quality and performance of the material used.
- iii) Any material considered to be sub-standard or not upto satisfaction of the Owner, shall not be used by the Contractor and shall be removed from the site immediately.
- iv) Representative samples shall be procured by the Contractor and submitted to the Owner for approval before bulk procurement. The representative samples shall be retained by the Owner for future comparison and reference.
- v) Materials, which shall be issued by the Owner, shall be as specified elsewhere in the Bid documents.

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### 1.3.0 CODES AND STANDARDS

- i) In the event of state, city or other local governmental bodies having requirements, more stringent than those set forth in this specification, the former shall govern.
- ii) All applicable standards, acts, specifications, codes of practice, handbook referred to herein shall be the latest editions, including all official amendments and revisions. In case of discrepancy between this specification and those referred to herein, this specification shall govern. Any special materials used, but not covered here, shall conform to relevant Indian Standards, if any, or as specified by the Owner for any special purpose.

iii) Some of the applicable Indian Standards, Codes are referred to here below:

IS:226	Specification for Structural steel (standard quality).
IS:269	Specification for Ordinary Portland Cement (Grade 33)
IS:383	Specification for coarse and fine aggregates from natural sources for concrete.
IS:432	Specification for mild steel and medium tensile steel bars (Part 1&2) and drawn steel-wires for concrete reinforcement.
IS:455	Specification for Portland slag cement.
IS:712:	Specification for building limes.
IS:1077	Specification for common burnt clay building bricks.
IS:1127	Recommendations for dimensions and workmanship of natural building stones for masonry work.
IS:1129	Recommendation for dressing of natural building stones.
IS:1489 (Part-I)	Specification for Portland-pozzolana cement Fly ash based.

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- (Part-II) Calcined clay based.
- IS:1542 Specification for sand for plaster.
- IS:1566 Specification for hard-drawn steel wire fabric for concrete reinforcement.
- IS:1597 Code of practice for construction (Part-I)of stone masonry, rubble stone masonry.
- IS:1786 Specification for high strength deformed bars for concrete reinforcement.
- IS:2062 Specification for structural steel (fusion welding quality).
- IS:2116 Specification for sand and masonry mortars.
- IS:2185 Specification for hollow and solid concrete blocks (Part-I).
- IS:2386 Testing of aggregates for concrete (Parts-I to VIII).
- IS:2691 Burnt clay face bricks.
- IS:3495 Methods of tests of burnt clay building bricks (Parts-I to IV).
- IS:4031 Methods of physical tests for hydraulic cement.
- IS:4032 Methods of chemical analysis of hydraulic cement.
- IS:4082 Recommendations on stacking and storage of construction materials at site.
- IS:7969 Safety code for handling and storage of building materials.
- IS:8112 High strength ordinary Portland cement. (Grade 43)
- IS:8500 Medium and high strength structural steel.
- IS:12269 Ordinary Portland cement (53 grade).
- IS:12330 Sulphate resisting Portland cement.

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IS:12600 Low heat Portland cement

IS:12894 Fly Ash Lime Bricks

## **1.4.0 TECHNICAL REQUIREMENTS**

### **1.4.1 MATERIALS**

#### **1.4.1.1 BRICKS**

- i) Burnt clay bricks, for general masonry work, shall conform to IS:1077 and for face brick work, shall conform to IS:2691. Fly ash lime bricks shall generally conform to IS:12894.
- ii) Bricks for general masonry work shall be table moulded / machine made, well burnt without being vitrified, of uniform size, shape, having sharp edges and cherry red colour. These shall be free from cracks, flaws or nodules of free lime and shall emit clear ringing sound (metallic sound) when struck together. These shall not show any signs of efflorescence either when dry or subsequent to soaking in water. Fractured surface shall show uniform texture free from grits, lumps, holes etc.
- iii) Unless otherwise specified, minimum compressive strength shall correspond to class designation 7.5 as per IS: 1077 with a minimum crushing strength of 75 kg./ sq.cm. for general masonry work. However, for non-load bearing walls, bricks pavements, etc., bricks of class designation 50 shall be used, wherever specified or as per requirement. Water absorption after 24 hours immersion shall not exceed 20% by weight for common bricks and 15% for face bricks.
- iv) On the basis of finish and dimensional tolerance, the bricks shall be classified as sub class A and B. Dimensional tolerance shall not exceed 3% and 8% of the sizes of common bricks for sub-class A & B respectively and 3% for face bricks. All bricks shall have rectangular faces and sharp straight edges. Maximum permissible chipping for the face bricks shall be 6mm at the edges and 10mm for corners. The face bricks shall show no efflorescence after soaking in water and drying in the shade.
- v) The size of the bricks used shall be either modular size as per IS:1077 or locally available conventional size as approved by the Owner.

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- vi) Each brick shall have the manufacturer's identification, marked clearly on the frog. The colour and texture of face bricks shall be limited to the range of samples submitted. Any brick not found upto the satisfaction of the Owner shall be removed immediately from site by the Contractor.

**1.4.1.2 STONES**

- i) All stones shall be from approved quarries. These shall be hard, tough, durable, compact grained, uniform in texture and colour and free from decay, flaws, veins, cracks and sand holes. The surface of a freshly broken stone shall be bright, clean and sharp and shall show uniformity of texture, without loose grains and free from any dull, chalky or earthy appearance. Stone with round surface shall not be used.
- ii) Stones showing mottled colours shall not be used for face work. Stone shall not absorb water more than 5% of its weight after 24 hours immersion. The type of stone shall be as specified or as per requirement and / or as instructed by the Owner. Stones used for masonry work shall conform to IS:1597 (Part -1). No soft stone shall be used for masonry or for filling purpose.
- iii) Any stone not found upto the satisfaction of Owner shall be removed immediately from site by the Contractor.

**1.4.1.3 CONCRETE BLOCKS**

Hollow cement concrete blocks shall conform to IS:2185. The blocks shall be uniform and of regular shape and size and shall meet the specified strength. Only full size blocks shall be used except when approved by Owner for making up wall length at specific locations. The blocks shall be properly cured and shall have such texture that plaster will adhere to them. Free issue cement from Owner shall not be used for making concrete blocks, unless otherwise specified.

**1.4.1.4 LIME**

- i) Lime shall conform to IS:712. Hydrated lime shall be mixed with water to form a putty. This shall be stored with reasonable care to prevent evaporation of water for at least 24 hours before use. Quick lime shall be slaked with enough water to make a cream and then stored with reasonable care to prevent evaporation of water for at least seven days before use. Type of lime to be used for different

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purposes such as concreting, plastering, white washing etc. shall be according to the classification made here under:

- Class-A Eminently hydraulic lime used for structural purposes.
- Class-B Semi-hydraulic lime used for masonry mortars, lime concrete and plaster undercoat.
- Class-C Fat-lime used for finishing coat in plastering, whitewashing, composite mortars, etc. and with addition of Pozzolan materials for masonry mortar.
- Class D Magnesium / dolomitic lime used for finishing coat in plastering, whitewashing, etc.
- Class-E Kankar lime used for masonry mortar.
- Class-F Siliceous dolomitic lime used for undercoat and finishing coat of plaster.

**1.4.1.5 CEMENT**

- i) Cement shall generally be Fly Ash based Portland pozzolana cement conforming to IS: 1489 (Part-I). However, ordinary Portland cement, 33-grade, conforming to IS:269 or Portland slag cement conforming to IS:455 may also be used, when permitted by the Owner. However, OPC, PPC and PSC should never be mixed. For producing higher grade of concrete, i.e. M-25 and above, and for construction of some critical structures viz., chimney, ID Cooling Tower, PA/ID/FD Fan Foundations, RCC Water Tank, Clarifiers etc., Ordinary Portland cement of grade 33 or grade 43 shall only be used. The contractor shall satisfy himself at the time of taking delivery from the Owner that the quality, quantity and freshness of cement are upto the specified standards. No complaint later regarding the quality of cement supplied by the Owner shall be entertained.
- ii) In case the cement being procured and used by the contractor is found unsatisfactory, the Owner reserves the right to suspend the work and send the samples of the cement to a testing laboratory for standard tests, at no extra cost to the Owner. The Contractor shall also have no claim for such suspension of work. Changing of type of cement within the same structure shall not be permitted without the prior approval of the Owner.

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**1.4.1.6 WATER**

- i) Water shall generally meet the quality requirements as stipulated in IS: 456. Water used for cement concrete, mortar, plaster, grout, curing, washing of coarse aggregate, soaking of bricks, etc. shall be clean and free from injurious amount of oil, acids, alkalis, organic matters or other harmful substances in such amounts that may impair the strength or durability of the structure. Potable water shall generally be considered satisfactory for all construction works, including curing. The Contractor shall carry out necessary tests in advance to prove the suitability of the water proposed to be used. As a guide, the following concentrations represent the maximum permissible values of impurities:
- a) To neutralize 200ml sample of water, it should not required more than 2ml of 0.1 normal NaOH.
- b) To neutralize 200ml sample of water, it should not require more than 10ml of 0.1 normal HCL.
- c) Percentage of solids shall not exceed the following:
- Organic 0.02
  - Inorganic 0.30
  - Sulphate 0.05
  - Chlorides 0.10
  - Suspended matter 0.20

**1.4.1.7 AGGREGATES**

- i) Aggregates mean both coarse and fine inert materials used in the preparation of concrete. Aggregates shall consist of natural sands, crushed stone and gravel from sources known to produce satisfactory aggregates for concrete and shall be chemically inert. Aggregates shall be hard, strong, and durable against weathering and of limited porosity. They shall be free from deleterious materials, which may cause corrosion of the reinforcement or may impair the strength and / or durability of the concrete. Total percentage of all deleterious materials, including coal, lignite, clay lumps, materials finer than 75 microns, soft fragments and shale but excluding mica shall not exceed 5%. However for crushed fine aggregate, total percentage of coal and lignite and clay lumps, shall be limited to 2%. Both coarse and fine aggregates shall conform to IS:383 with proper gradation, for concrete, shotcreting etc. unless otherwise specified.

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- ii) Sample of aggregates for mix design and determination of their suitability shall be sent to the laboratory well in advance, of scheduled commencement of concrete / masonry works. Sampling, testing and interpretation of test results shall be subject to the approval of the Owner.

**1.4.1.8 SAND**

Sand shall be hard, durable, clean and free from adherent coatings of organic matter and shall not contain clay balls or pellets. The sand shall be free from impurities such as iron pyrites, alkalis, salts, coal, mica, shale or other laminated materials in such forms or quantities so as to affect adversely on hardening, strength, durability or appearance of mortar, plaster, etc. or to cause corrosion of any metal in contact with such mortar, plaster, etc. In no case, the cumulative percentage of impurities in sand shall be more than 5% by weight. All sand shall be properly graded. Unless otherwise directed by the Owner, sand for masonry mortars shall conform to IS:2116 and sand for plaster shall conform to IS:1542. Sand, when used as fine aggregate, in concrete, shall conform to IS:383. For filling, medium grained sand (having fines less than 75 microns not exceeding 20%) shall be used.

**1.4.1.9 REINFORCEMENT STEEL, STRUCTURAL STEEL (INCLUDING EMBEDDED STEEL) AND WIRE MESH**

- i) All steel for reinforcement shall be clean and free from loose mill scales, dust, loose rust, oil, grease, paint or other harmful matters, which may affect its bond with concrete. Mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement shall conform to grade-1 (Fe-250) of IS:432 (Part1). High strength deformed steel bars shall conform to grade Fe 415 of IS:1786. All steel bars shall be of tested quality. Actual grade and type of steel, to be used, shall be as specified or as required.
- ii) Structural steel (including embedded steel) shall be straight, sound, free from twists, cracks, flaws, laminations and all other defects. Structural steel shall be of tested quality conforming to IS:226, IS:2062 or IS:8500. Grade and type of steel to be used shall be as specified.
- iii) Hard drawn steel wire fabric shall conform to IS:1566. Wire fabric shall be electrically cross welded.

**1.4.2 STORAGE AND HANDLING OF MATERIALS**

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- i) Generally, all materials shall be stacked and stored by the Contractor as described in IS:4082 unless otherwise mentioned and in a manner affording convenient access for identification and inspection at all times. The storage area and arrangements shall be subjected to the approval of the Owner. Any material rendered unserviceable in Contractor's custody, shall be replaced or repaired by the Contractor as determined by the Owner.
- ii) All materials shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which was deteriorated or has been damaged or is otherwise considered defective by the Owner, shall not be used and shall be removed and the cost thereof, shall be realized from the Contractor's dues. The Contractor shall maintain upto date accounts of receipts, Issue and balance stocks of all materials.
- iii) Bricks shall not be dumped at site. These shall be stacked on dry firm ground in regular tiers even as they are unloaded to minimize breakage and defacement. Bricks of different class, selected for various categories of use in the work, shall be stacked separately. Each stack shall contain equal number of bricks, preferably not more than 3000.
- iv) Dressed stone for all facing, paving etc. shall be stored with special care to avoid defacement of edges and faces or damp and rust stains.
- v) Lime shall be stored in weather-proof sheds. Lime, which has been damaged by rain, moisture or air slaking, shall not be used. If the lime is supplied as hydrated lime, it shall be stored in the same manner as cement.

**1.4.2.1 CEMENT**

- i) Consignments of cement shall be stored as received and shall be consumed in the order of their delivery. Cement held in storage for more than ninety days shall invariably be tested and only if test results are satisfactory, the Owner may consider permitting its use.
- ii) Different consignments of different types of cement i.e. OPC, PPC, PSC shall be stacked separately with clear identifiable stack number.
- iii) The cement shall be stored in dry, leak proof and weather proof enclosed sheds. Storage under tarpaulins shall not be permitted. The cement bags shall be stored well away from the walls and insulated from the floor using wooden planks etc.,

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to avoid contact with moisture. The cement shall be stacked in easily countable stacks and in a place of easy access so as to facilitate proper inspection and removal on a first in first out basis. Not more than 15 bags shall be stacked in any tier to prevent lumping up under pressure. However, in stacks more than 8 bags high, the cement bags shall be arranged alternately lengthwise and crosswise so as to tie the stacks together and minimize the danger of toppling over. The cement bags shall be gently kept to avoid leakage of cement from the bags. Substandard or partially set cement shall be immediately removed from the site as soon as it is detected.

- iv) The Contractor shall make his own arrangements for the storage of adequate quantity of cement as approved by the Engineer. Cement in bulk may be stored in bins or silos, which will provide adequate protection against dampness, contamination, etc. The bins or silos shall be cleaned periodically.

**1.4.2.2 COARSE AND FINE AGGREGATES/SAND**

- i) Coarse and fine aggregates shall be stacked separately. Contamination with foreign materials and earth during storage and while heaping the materials shall be avoided. Coarse aggregates shall be stacked in layers not exceeding 120 cm in height such that coning and segregation do not occur. Each layer shall cover the entire area of the stockpile before succeeding layers are placed. Segregated aggregates from stockpile shall be rejected.
- ii) Aggregates shall be stored on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass or any other injurious substance, at any stage. For lifting aggregates from stockpiles, rakers shall be used. Aggregates of different sizes shall be kept in separate and easily measurable stacks. If so desired by the Owner, aggregates from different source shall be stacked separately with proper care to prevent intermixing.

**1.4.2.3 REINFORCEMENT AND STRUCTURAL STEEL (INCLUDING STEEL REQUIRED FOR EMBEDMENT)**

- i) Reinforcement and Structural steel (including steel required for embedment) shall be stored consignment wise and size wise, above the ground by at least 150mm and protected by a suitable cover or as desired by the Owner. The steel shall be protected from rusting, oil, grease and distortions. The reinforcing steel shall be coated with cement wash before stacking to prevent scale and rust, in areas having accelerating corrosion effect like marine atmosphere. The stacks shall be easily measurable. Steel needed for immediate use only shall be

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removed from storage. Fabricated steel shall be carefully stored to prevent damage, distortion, corrosion and deterioration.

- ii) Reinforcement shall be stored according to the diameter, grade and length in such a place as to permit easy approach for inspection and identification.
- iii) The area shall be such that water does not accumulate and reinforcement does not get distorted or corroded. It shall not be stacked directly over ground or near any harmful materials. It shall be cleaned of excessive rust before use as desired / directed by the Engineer.
- iv) Steel plates of different specifications shall be stacked separately. Steel of IS:2062 and IS:8500 quality shall be given a grade wise, distinctive identification mark. Passage and space between the stacks shall be sufficient for rigging operations.

### **1.5.0 TESTING**

All materials provided by the Contractor shall be tested for conformity with respect to the relevant specification and the test results shall be submitted to the Owner for acceptance. In addition to above, the Contractor shall carryout the relevant tests at site as specified under different items of work and as per approved field quality plan.

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**TECHNICAL SPECIFICATION FOR CAST-IN-SITU CONCRETE AND  
ALLIED WORKS**

**END USER** **MADHYA PRADESH POWER GENERATING  
COMPANY LIMITED**

**LTSL PROJECT No.** **T 408000**

**LTSL DOC. No** **MALWA-SP-C-003**

**REVISION CERTIFICATION**

REV NO.	DATE OF ISSUE	PREPARED					REVIEWED					APPROVED
		MECHANICAL	ELECTRICAL	CIVIL	INSTRUMENTATION	PROCESS	MECHANICAL	ELECTRICAL	CIVIL	INSTRUMENTATION	PROCESS	
P0	31/7/06											
A	15/9/06											
B	30/4/07											

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**TECHNICAL SPECIFICATION FOR  
CAST-IN-SITU CONCRETE AND ALLIED WORKS**

**1.0.1 INTENT**

- i) The work shall include providing of materials, all necessary plants and equipment, providing adequate engineering supervision and technical personnel, skilled and unskilled labour, etc. as required to carry out the entire work as indicated on the drawings and/or described herein subsequently and/or as directed by the Owner.
- ii) The Contractor shall carry out all works meant within the intent of this specification even if not explicitly mentioned herein. All works shall be executed to the satisfaction of the Owner.
- iii) This specification is divided into 13 Divisions. This division deals with common requirements and the other 13 Division deals with specifications for 13 different items/activities. The stipulations contained herein shall form a part of the specifications of 13 different items/activities described in Division I to XIII

All these thirteen Division are as follows:

DIVISION - I	Cast-in-Situ Concrete
DIVISION - II	Reinforcement
DIVISION - III	Formwork and staging
DIVISION - IV	Embedded parts
DIVISION - V	Foundation bolt assembly
DIVISION - VI	Shotcreting
DIVISION - VII	Grouting
DIVISION - VIII	Encasement of steel structures/elements
DIVISION - IX	Joints in Concrete
DIVISION - X	Water proofing/damp proofing of Concrete structures.
DIVISION - XI	Dismantling/Demolishing works-RCC and PCC.
DIVISION - XII	Cement Additives/Admixtures in concrete.
DIVISION - XIII	Concreting of major equipment foundations.

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- iv) Precast and prestressed concrete work specification, have been dealt separately. Special requirements for machine foundations like BFP, TG, fan, mill and crusher foundation, chimney, natural draught cooling tower, piling, etc. have been covered in this specification separately in Division XIII and also applicable clauses of this specification / other specifications shall be followed for the construction of the Machine foundation.

### **1.0.2 GENERAL REQUIREMENTS**

- i) Any approval, instructions, permission, checking, review, etc. whatsoever by the Owner, shall not relieve the Contractor of his responsibility and obligation regarding adequacy, correctness, completeness, safety, strength, quality, workmanship, etc.
- ii) The Contractor shall make his own surveying arrangements for locating the coordinates and positions of all work and establishing the reduced levels (RLs) at these locations, based on two reference grid lines and bench mark. The Contractor has to provide at site, all the required survey instruments, along with qualified surveyors, to the satisfaction of the Owner so that the work can be carried out accurately and according to the specifications and drawings.
- iii) Work to be provided by the contractor:

The work to be provided for by the Contractor, unless otherwise specified shall include but not be limited to the following

- Furnish all labour, supervision, services including facilities as may be required under statutory labour regulations, materials, forms, templates, supports, scaffolds, approaches, aids, construction equipment, tools and plants, transportation, etc. required for the work.
- Prepare Bar bending Schedules for reinforcement bars showing the positions and details of spacers, supports, chairs, hangers etc.
- Prepare working drawings of form works, scaffolds, supports, etc.
- Prepare shop drawings for various inserts, anchors, anchor bolts, pipe sleeves, embedment, hangers, openings, frames etc.
- Prepare detailed drawings of supports, templates, hangers, etc. required for installation of various embedment like inserts, anchor bolts, pipe sleeves, frames, joint seals, frames, openings etc.

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- As decided by the Engineer some or all of the drawings & schedules prepared as mentioned above will have to be submitted for approval.
- Submit for approval detailed schemes of all operations required for executing the work, e.g. material handling, Concrete mixing, Placement of concrete, Compaction, curing, services, Approaches, etc.
- Design and submit for approval the concrete mix designs that are required to be adopted on the job.
- Furnish samples and submit for approval results of tests of various properties of the following:
  - i) The various ingredients of concrete
  - ii) Concrete
  - iii) Embedment
  - iv) Joint seals
- Provide all incidental items not shown or specified in particular but reasonably implied or necessary for successful completion of the work in accordance with the drawings and specifications.
- For supply of certain materials normally manufactured by specialist firms, the Contractor may have to produce, if directed by the Engineer, a guarantee in approved Performa for satisfactory performance for a reasonable period as may be specified, binding both the manufacturers and the Contractor, jointly and severally.

iv) Work by others:

No work under this specification will be provided by any agency other than the Contractor unless specifically mentioned elsewhere in the contract.

### **1.0.3 CODES AND STANDARDS**

- i) All applicable standards, specifications, etc. and codes of practice shall generally be the latest editions, including all applicable official amendments and revisions. A complete set of all these documents shall generally be made available at site by the Contractor.

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- ii) All work shall be carried out as per the stipulations contained in various Divisions of these specifications and the latest Indian Standards, Acts, Codes and best practices.
- iii) In case of conflict between the stipulations contained in various Divisions of these specifications and stipulations of Indian Standards, Codes, etc., the requirements of stipulations contained in various Divisions of these specifications, shall prevail over that of Indian Standards, Codes, etc.

iv) Some of the applicable Indian Standard Codes, etc. are referred to here below:

IS:73	Specification for paving bitumen.
IS: 216	Indian Standard Specification for Coal Tar Pitch
IS:226	Specification for structural steel (standard quality).
IS:269	Specification for Ordinary Portland cement, 33 grade.
IS:280	Specification for mild steel wire for general engineering purposes.
IS:383	Specification for coarse and fine aggregates from natural sources for concrete.
IS:432	Specification for mild steel and medium tensile steel bars and hard (parts I & II) drawn steel wire for concrete reinforcement.
IS:455	Specification for Portland slag cement.
IS:456	Code of practice for plain and reinforced concrete.
IS:457	Code of practice for general construction of plain & reinforced concrete for dams & other massive structures.
IS:516	Method of test for strength of concrete.
IS:650	Specification for standard sand for testing of cement.

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IS:702	Specification for industrial bitumen.
IS:816	Code of practice for use of metal arc welding for general construction in mild steel.
IS:1199	Methods of sampling and analysis of concrete.
IS:1200	Method of measurement of building and civil engineering works. (Part-II, V, VIII, water proofing and damp proofing. XVIII)
IS: 1322	Indian Standard Specification for Waterproofing and Damp-proofing Bitumen Felts for Waterproofing and Damp-proofing.
IS:1367	Technical supply conditions for threaded steel fasteners.
IS:1489 (Part-I) (Part-II)	Specification for Portland-pozzolana cement. Fly ash based. Calcined clay based.
IS:1566	Specification for Hard-drawn steel wire fabric for concrete reinforcement.
IS: 1609	Code of practice for laying damp proof treatment using bitumen felts.
IS:1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.
IS:1791	General requirements for batch type concrete mixers.
IS:1838	Specification for preformed fillers for expansion joints in concrete (Part-I)pavements and structures (non-extruding and resilient type).
IS:2185	Indian Standard Specification for Hollow Cement Concrete Blocks

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IS:2204	Code of practice for construction of reinforced concrete shell roof.
IS:2210	Criteria for the design of reinforced concrete shell structures and folded plates.
IS:2386 (Parts I to VIII)	Methods of test of aggregates for concrete.
IS:2438	Specification for roller pan mixer.
IS:2502	Code of practice for bending and fixing of bars for concrete reinforcement.
IS:2505	General requirements for concrete vibrators, immersion type.
IS:2506	General requirements for concrete vibrators, screed board type.
IS:2514	Specification for concrete vibrating tables.
IS:2571 IS:2645	Code of practice for laying in-situ cement-concrete flooring. Specification for Integral cement water proofing compounds.
IS:2722	Specification for portable swing weigh batchers for concrete. (single and double bucket type)
IS:2750	Specification for Steel scaffoldings.
IS:2751	Code of practice for welding of mild steel plain and deformed bars for reinforced concrete construction.
IS: 2770	Indian Standard Specification for Method of Testing Bond in Reinforced Concrete
IS:3025	Methods of sampling and test waste water.

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IS:3067	Code of practice for general design details and preparatory work for damp proofing & water proofing of building.
IS:3150	Specification for hexagonal wire netting for general purposes.
IS:3366	Specification for Pan vibrators.
IS:3370 (Part I to IV)	Code of practice for concrete structures for the storage of liquids.
IS:3384	Specification for bitumen primer for use in waterproofing & damp proofing.
IS:3414	Code of practice for design and installation of joints in the buildings.
IS:3550	Methods of test for routine control for water used in industry.
IS:3558	Code of practice for use of immersion vibrators for consolidating concrete.
IS:3696 (Part I & II)	Safety code for scaffolds and ladders.
IS: 3812	Indian Standard Specification for Fly Ash for Use as Admixture for Concrete
IS:4014 (Parts I & II)	Code of practice for steel tubular scaffolding.
IS:4031	Methods for physical tests for hydraulic cement.
IS: 4082	Indian Standard Specification for Recommendation on Stacking and Storage of Construction Materials at site
IS:4130	Safety codes for demolition of buildings.

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IS:4326	Code of practice for earthquake resistant design and construction of buildings.
IS:4461	Code of practice for joints in surface hydro-electric power stations.
IS: 4634	Indian Standard Specification for Method of Testing Performance of Batch-type Concrete Mixes
IS:4656	Specification for form vibrators for concrete.
IS:4925	Specification for batching and mixing plant.
IS: 4926	Indian Standard Specification- for Ready-Mixed Concrete
IS:4990	Specification for plywood for concrete shuttering work.
IS:4995 (Parts I & II )	Criteria for design of reinforced concrete bins for the storage of granular and powdery materials.
IS: 4998	Indian Standard Specification for Design- of Reinforced Concrete Chimneys.
IS:5121	Safety code for piling and other deep foundations.
IS:5256	Code of practice for sealing joints in concrete lining on canals.
IS:5512	Indian Standard Specification for Flow Table for use in Tests of Cement and Pozzolanic materials.
IS: 5513	Indian Standard Specification for vacate Apparatus.
IS:5515	Indian Standard Specification for Compaction Factor Apparatus.
IS:5525	Recommendations for detailing of reinforcement in reinforced concrete work.

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IS:5624	Specification for foundation bolts.
IS: 5751	Indian Standard Specification for Precast Concrete Coping Blocks.
IS: 5816	Indian Standard Specification for Method of Test for Splitting Tensile strength of Concrete Cylinders.
IS: 5891	Indian Standard Specification for Hand operated Concrete Mixers.
IS: 5892	Indian Standard Specification for transit mixer and agitators.
IS: 6452	Indian Standard Specification for High Alumina Cement for Structural Use
IS:6461	Glossary of terms relating to cement concrete.
IS:6494	Code of practice for water proofing of underground water reservoirs and swimming pools.
IS:6509	Code of practice for installation of joints in concrete pavements.
IS: 6909	Indian Standard Specification for Super sulphated Cement
IS: 6923	Indian Standard Specification for Method of Test for Performance of Screed Board Concrete Vibrators.
IS: 6925	Indian Standard Specification for Method of Test for Determination of Water Soluble Chloride in Concrete Admixtures.
IS: 7242	Indian Standard Specification for Concrete Spreaders.
IS: 7246	Indian Standard Specification for Table Vibrators for Consolidating Concrete.

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IS: 7251	Indian Standard Specification for Concrete Finishers.
IS:7193	Specification for glass fiber base coal- tar pitch and bitumen felts.
IS:7293	Safety code for working with construction machinery.
IS: 7320	Indian Standard Specification for Concrete Slump Test Apparatus.
IS:7861 (Parts I & II)	Code of practice for extreme weather concreting.
IS: 8041	Indian Standard Specification for Rapid Hardening Portland cement.
IS:8112	Indian Standard Specification for high strength Ordinary Portland Cement.
IS: 8142	Indian Standard Specification for Determining Setting time of concrete by Penetration Resistance.
IS: 8989	Safety Code for Erection of Concrete Framed Structures.
IS:9012	Recommended practice for shotcreting.
IS: 9013	Indian Standard Specification for Method of Making, Curing, and determining compressive Strength of Accelerated-cured Concrete Test Specimens.
IS: 9077	Code of Practice for Corrosion Protection of Steel Reinforcement in RB and RCC Construction.
IS:9103	Specification for admixtures for concrete.
IS:9417	Recommendations for welding cold-worked steel bars for reinforced concrete construction.

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IS:9595	Recommendations for metal-arc welding of carbon and carbon manganese steels.
IS: 10262	Recommended guidelines for concrete mix design.
IS: 11384	Code of practice for composite construction in structural steel and concrete.
IS:12118	Specification for two-parts polysulphide.
IS:12200	Code of practice for provision of water stops at transverse contraction joints in masonry and concrete dams.
IS:12269	53 Grade ordinary Portland cement.
IS:12600	Portland cement, low heat.
IS: 13311	Non-destructive testing of concrete.
SP:23	Handbook of concrete mixes.
SP:24	Explanatory Handbook on IS:456-1978.
SP:34	Handbook on concrete reinforcement and detailing.

#### **1.0.4 TECHNICAL REQUIREMENTS – INSTALLATION**

For technical requirement of mixing / fabrication and laying / installation / Erection of Cast-in-Situ Concrete and allied works, refer to each Division of this specification.

#### **1.0.5 SAMPLING, TESTING AND QUALITY ASSURANCE**

- Facilities required for sampling materials, concrete, reinforcement formwork, etc. in the field and in the laboratory shall be provided by the Contractor. The Contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and/or International Standards, this specification and approved field quality plan. Where no specific testing procedure is mentioned,

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the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Owner. Tests shall be done in the field in the presence of the Owner or his authorised representative and at a laboratory, approved by the Owner, and the Contractor shall submit to the Owner the test results in triplicate within three days after completion of any test or as directed by the Owner.

- ii) The Contractor shall maintain records of all inspection and testing, which shall be made available to the Owner. The Owner, at his discretion, may waive some of the stipulations for small and unimportant concreting operations and other works.
- iii) Work, found unsuitable for acceptance, shall be removed and replaced by the Contractor. The work shall be redone as per specification requirements and to the satisfaction of the Owner at no extra cost to the Owner.

**1.0.5.1 QUALITY ASSURANCE PROGRAMME**

- i) The Contractor shall submit and finalise a detailed field Quality Assurance Programme within 30 days from the date of award of the contract, before commencement of work at site, according to the requirements of the specification. This shall include setting up of a testing laboratory, arrangement of testing apparatus / equipment, deployment of qualified / experienced manpower, preparation of format for record, field quality plan, etc. On finalised field quality plan, the Owner shall identify customer hold points, beyond which work shall not proceed without written approval from the Owner. The testing apparatus / equipment installed in the field laboratory shall be calibrated/corrected by the authorised persons, recommended by the Manufacturer or as required, to give accurate testing results.
- ii) Frequency of sampling and testing, etc. and acceptance criteria are given in Table 1. However, the testing frequencies set forth are the desirable minimum and the Owner shall have the full authority to call for additional tests as frequently as he may deem necessary to satisfy himself that the material and works comply with the appropriate specifications.

**TABLE 1**

**FREQUENCY OF SAMPLING AND TESTING**

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SR. NO.	Nature of test/ Characteristics	Method of Test	No. of samples & frequency of Test	Remarks
<b>I</b>	<b>COARSE AGGREGATES</b>			
	a) Particle size and shape	IS:2386(Pt.1)	One per 100 Cu.m. or part thereof or change of source whichever is earlier	Results to be as per the requirement of design mix, subject to variations within the limits specified in relevant Indian Standards.
	b) Moisture content	IS:2386(Pt.3)	Once for each stack of 100 Cu.m. of part thereof except during monsoon when this has to be done every day before starting of the work.	Accordingly, water content of the concrete shall be adjusted.
	c) Specific gravity, density, voids absorption.	IS:2386(Pt.3)	Once in 12 weeks or change of source, whichever is earlier.	These tests shall be carried out while establishing design mix and results to be intimated.
	d) Mechanical properties, crushing value, abrasion value and impact value.	IS:2386(Pt.4)	Once per source	Acceptance norms shall be as per IS:383.
	e) Soundness	IS:2386(Pt.5)	Once per source	Acceptance norms shall be as per IS:383.
	f) Reaction with alkali	IS:2386(Pt.7)	Once per source	These tests shall be carried out while establishing design mix and result to be intimated. Acceptance shall be as per IS: 2386(Pt7.)

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SR. NO.	Nature of test/ Characteristics	Method of Test	No. of samples & frequency of Test	Remarks
	g) Flakiness and Petrographic examinations	IS:2386	This is to be done once and should be repeated in case the source is changed	These tests shall be carried out while establishing design mix and results to be initiated
	h) Deleterious materials	IS:2386(Pt.2)	Once per source	Results should be within the limit as specified in relevant Indian Standard and in this specification.
<b>II.</b>	<b>FINE AGGREGATES / SAND</b>			
	a) Particle size and shape.	IS: 2386 (Pt.1)	One per 100 cu. m. or part thereof or change of source, whichever is earlier.	Should be as per the requirement of design mix, subjected to variation within the limit as specified in relevant IS code.
	b) Specific gravity, density, voids, absorption and bulking.	IS: 2386 (Pt.3)	Once in 12 weeks or change of source whichever is earlier.	These tests will be carried out while establishing design mix and results to be intimated.
	c) Bulkage, moisture content(Routine test)	IS :2386 (Pt.3)	To be done everyday before start of work.	Volume of sand and weight of water shall be adjusted as per Bulkage and moisture content.
	d) Silt, clay, deleterious materials, and organic impurities.	IS: 2386 (Pt.2)	Once per source to be repeated, if source is changed.	Acceptance norms shall be as per IS : 383.
	e) Soundness and	IS : 238	Once per source	Acceptance norms shall

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SR. NO.	Nature of test/ Characteristics	Method of Test	No. of samples & frequency of Test	Remarks
	Petrographic examination.	(Pt. 5 & 8)		be as per IS : 383.
	f) Mortar making properties.	IS: 2386 (Pt.6)	Once per source	Acceptance norms shall be as per IS : 383.
	g) Reaction with alkali.	IS: 2386 (Pt.7)	Once per source	Acceptance norms shall be as per IS : 383 and IS : 2386(Pt.7)
<b>III.</b>	<b>CEMENT</b>			
	a) Setting time.	IS : 4031	One sample of each received from stores.	Acceptance norms shall be as per relevant Indian Standards.
	b) Compressive strength.	IS : 4031	One sample of each received from stores.	Acceptance norms shall be as per relevant Indian Standards.
	C) Fineness	IS : 269	One sample of each received from stores.	Acceptance norms shall be as per relevant Indian Standards.
	D) Soundness	IS : 269	One sample of each received from stores.	Acceptance norms shall be as per relevant Indian Standards.
<b>IV.</b>	<b>WATER</b>			
	Harmful substances, pH value, initial setting time, compressive strength.	IS : 3025, IS : 4031 & IS : 516 IS : 3550	Once a month for each source.	Acceptance norms shall be as per Clause 5.4 of IS: 456

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SR. NO.	Nature of test/ Characteristics	Method of Test	No. of samples & frequency of Test	Remarks
<b>V.</b>	<b>CONCRETE</b>			
	a) Workability (Slump and compaction factor).	IS : 1199	One sample every two hours from every fixing plant.	Acceptance value shall be as per Clause 7.1 of IS : 456
	b) Crushing strength	IS : 516	i) As per Clause 15.2.2 of IS: 456 for initial period.	Acceptance criteria shall be as per Clause 16 of IS : 456.
			ii) One sample of six cubes per 150 cu. m. or part there of mass concrete for subsequent period.	A minimum of 3 specimens shall be tested for 28 days strength.
	c) Water Cement Ratio.	IS : 1199	At random at the time of batching.	According to mix design.
	d) Cement content	IS : 1199	At random at the time of batching	According to mix design.
	e) Water tightness test for (water retaining structures)	IS : 3370	Each tank or reservoir.	Acceptance criteria as per specification.
	f) Finished dimensions	Physical measurement	All structures	Acceptance as per Specifications.
<b>VI.</b>	<b>FORM WORK</b>			
	a) Staging (Durability, strength &	Visual	Each member	Any staging intended for use shall be approved by the Owner for its

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SR. NO.	Nature of test/ Characteristics	Method of Test	No. of samples & frequency of Test	Remarks
	soundness of staging, joints, adequacy of its foundation and specific level)			durability and strength.
				After erection of staging, nominated representatives of Owner shall check the soundness of the staging as a whole, its joints, adequacy of its foundation and the specific levels.
	b) Shuttering			
	i) Materials	Visual	Random	Formwork materials shall be strictly as per specifications and approval of the Owner. Materials for formwork shall be unwrapped, thoroughly clean and without broken or damaged edges either due to repetitive use or otherwise. Oiling of formwork before concreting shall be resorted to.
	ii) Joints	Visual	Random	Joints shall be leak-proof to avoid loss of liquid.
	iii) Dimensions and plumb	Physical measurement	Each member and before every lift.	Tolerance as per Specification.
<b>VII</b>	<b>REINFORCEMENT</b>			
	a) Placement	Visual	each	The bar bending schedule

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SR. NO.	Nature of test/ Characteristics	Method of Test	No. of samples & frequency of Test	Remarks
				with the necessary hooks, laps, covers, spacers and chairs shall be 100% checked for all concreting works before start of work.
	b) Cutting tolerance	Physical measurement	Random	Tolerance shall be as per specification.
	c) Freedom from defects	Visual	Random	Any of the bars selected for use shall be free from cracks, surface flaws, laminations and rough, jagged and imperfect edges.
<b>VIII</b>	<b>EMBEDDED PARTS</b>			
	a) Type of embedment	Visual	Each part	Type/Details as per drawings. Tolerance as per specifications.
	b) Location and	Physical	Each part	Details as per drawings. Tolerance as per specifications.



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**DIVISION - I**

**CAST-IN-SITU CONCRETE**

**1.1.1 INTENT**

This Division of the specification deals with plain or reinforced cement concrete for general use and in structures and covers the requirements for concrete, materials, their properties, storage, handling, grading, mix design, strength and quality, pouring at all levels, testing, casting, protecting, curing, finishing, etc.

**1.1.2 GENERAL REQUIREMENTS**

- i) This part of the specification covers the requirement for plain and or reinforced cement concrete for all kinds of work such as building up of piles, pilecap, foundations including machine foundations, pedestals, columns, beams, slabs, lintels, floors, roofs, parapets, fascia, flooring, under bed, screed concreting, concreting over metal decking, encasement of structures, area paving, trenches, drains, pits, sumps, rigid foundation for rail-tracks, manholes, culverts, walls, tanks, coping, jambs, waist slabs, soffits of stairs, risers, treads, canopy, portico, grade slab, decks supported on vibration isolation system, basement, cable vault, etc.
- ii) For the concreting work in piling, specification for concreting as specified under piling chapter shall also be referred to in addition to the specification covered herein. In case of conflict between stipulation in piling chapter and this chapter, the specification covered under piling chapter shall prevail.
- iii) The provisions of IS:456 shall be followed as general guidance, along with all other relevant Indian Standards, unless otherwise specifically mentioned. Contractor shall deploy mechanised system for production, transportation and placement of concrete.
- iv) At least one week before commencing the construction of any large concrete section, the Contractor shall submit, for approval of the Owner, detailed proposals for placing the concrete to demonstrate the suitability of the methods.

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### 1.1.2.1 MATERIALS

In general, all the materials used in the manufacture of concrete shall be in accordance with the Technical Specification for Properties, Storage and Handling of Common Building Materials, which shall be deemed to form a part of this specification.

The Owner shall have the right to inspect the sources of materials, method of procurement and storage of materials, quality control procedures, etc.

#### A) Cement

Cement shall be ordinary Portland cement (Grade-43) conforming to IS:8112 and / or fly ash based Portland Pozzolona cement conforming to IS:1489 (Part-I) and / or any other type of cement, meeting IS:456 requirement.

Other types of cement such as Ordinary Portland Cement conforming to IS: 269, Portland slag cement conforming to IS: 455 respectively can be used under special circumstances. Cement used in all concrete mixes shall be in general of grade 33/43 unless design requires a higher grade.

In special cases, Rapid Hardening Portland Cement, Low Heat Cement, Sulphate resistant cement, high strength Ordinary Portland Cement etc. may be permitted or directed to be used by the Engineer.

For Brickwork, plaster, flooring and other finishing works, ordinary Portland cement of 33/43 grades shall be used.

#### B) Aggregates

i) Aggregates mean both coarse and fine inert materials used in the preparation of concrete. Aggregates shall consist of natural sand and / or crushed stone from a source known to produce satisfactory aggregate for concrete and shall conform to IS:383

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- ii) The maximum size of coarse aggregates for different locations shall be as follows unless otherwise directed by the Engineer

Very narrow space	12 mm
Reinforced concrete Except foundation	20 mm
Ordinary Plain concrete and Reinforced concrete foundations	40 mm
Mass concrete.	80 mm
Lean concrete	40 mm

- iii) Petrographic examination of aggregate shall be carried out by the Contractor at National Council and Building Materials (NCB), Ballabgarh, or any other approved laboratory to ascertain the structure and rock type including presence of strained quartz and other reactive minerals for machine foundations, etc., and other structures as specified in schedule of items. Moreover, in case, the coarse aggregate sample is of composite nature, the proportions (by weight) of different rock types in the composite sample and petrographic evaluation of each rock should also be ascertained. While determining the rock type, special emphasis should be given on identification of known reactive rocks like chalcedony, opal, etc. The Procedure laid down in IS: 2430 for sampling of aggregates may be followed.
- iv) The laboratory test shall determine potential reactivity of the aggregate, which may lead to reaction of silica in aggregate with the alkalis of cement and / or potential of some aggregates like limestone to cause residual expansion due to repeated temperature cycle. If the same is established, the contractor shall further carry out alkali aggregates reactivity test as per IS:2386 (Part VII) and / or repeated temperature cycle test to establish the suitability of the aggregates for the concrete work. The test results, with final recommendations of the laboratory, as to a suitability of the aggregate, for use in the concrete work for various structures and suggested measures, in case of results are not satisfactory, shall be submitted to the Owner for his review, in report form.
- v) In case in the report, it is established, than the aggregates contain reactive silica, which would react with alkalis of the cement, the contractor shall change the source of supply of the aggregate or take measures as recommended in the report as instructed by Owner. In case aggregates



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indicate residual expansion, under repeated temperature cycle test (from 10 °Celcius to 65 °Celcius and for temperature cycles) the material shall not be used for concreting of TGs', BFP', Fans, mills and other equipment foundations which are likely to be subjected to repeated temperature cycle. The contractor shall use aggregates free from residual expansion under repeated temperatures cycle test.

**C) Pozzolanas (Fly Ash)**

Fly ash for use in concrete and allied works shall conform to Grade-1 of IS:3812. The fly ash shall be collected in closed container from below the existing ESP / Dry Fly Ash Silos and tested for blaine's fineness (value should be more than 3200 Sq.cm./gm.). Mixing of fly ash for making concrete shall be done in proportion as per the mix design.

**D) Admixtures**

Admixtures in concrete for promoting workability, improving strength, entraining air for similar purposes may be used only after the written permission from the Owner is obtained. These shall be free from, injurious amount of chloride, etc. Addition of admixtures should not reduce the specified strength or durability of concrete and should not have detrimental effect on reinforcement. The admixtures shall conform to IS:9103 and shall be of proven make and from a reputed manufacturer. Calcium chloride as accelerating admixture is not permitted to be used other than in mass concrete works. The Contractor shall produce latest test results carried out at approved Government Test Houses for the approval of the Owner, before use. Details of admixtures have been covered elsewhere in relevant specifications.

**E) Water**

i) Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, sugar, organic materials, or other substances that may be deleterious to concrete or steel. Potable water i.e. generally considered satisfactory for mixing concrete. The maximum permissible values of impurities shall be as given in Clause 5.4 of IS: 456.

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- ii) In case of doubt regarding development of strength. the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time tests specified in IS:456.
- iii) Average 28 days compressive strength of at least three 150mm concrete cubes prepared with water proposed to be used shall not be less than 90% of the average strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with IS:456.
- iv) The initial setting time of test block made with the appropriate cement and the water proposed to be used shall no be less than 30 minutes and shall not differ by  $\pm 30$  minutes from the initial setting time of control test block prepared with the same cement and distilled water. The test blocks shall be prepared and tested in accordance with the requirements of IS: 4031 (Part5).
- v) Where concrete, made from water, proposed to be used does not satisfy the above requirements and/or contains an excess of acid. alkali, sugar, salt or other deleterious, substances, then the Owner may refuse to permit its use. Sea water shall not be used for curing besides mixing in concrete.

**F) Grades of Concrete**

All concrete shall be "design mix concrete ' as defined in IS:456, unless a nominal mix concrete such as 1:2:4, 1:3:6, 1:4:8 or 1:5:10 proportion is specified. The proportion referred to is by weight (mass). The grades for 'design mix' concrete shall be designated M-15, M-20, etc. as specified in IS:456.

i) Nominal mix Concrete

- Nominal mix shall conform to Clause 9.3 of IS:456. Nominal mix concrete shall be used only for plain Cement concrete works as specifically allowed by the Owner. Such concrete shall not require preparation of trial mixes and all such concrete shall be mixed in a mechanical mixer. proportions for nominal mix concrete shall be according to Table-9 of IS:456. In addition standard proportion by volume shall he used wherever specified.

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- In proportioning concrete, the cement shall be measured by (mass) weight. The quantities of fine and coarse aggregates may be determined by volume (for corresponding weight) but preferably by weight. If fine aggregates are moist, the amount of surface water shall be determined. Also an allowance shall be made for bulking in case of volume batching, in accordance with IS:2386 (Part-III). Allowance shall also be made for surface water present in the aggregates, when computing the water requirement. All the above data shall be maintained properly, to the satisfaction of the Owner.
- The recommended maximum water cement ratios are specified in Table 2.

**TABLE 2**

**RECOMMENDED WATER-CEMENT RATIO**

Nominal mix concrete per bag of 50 Kg cement (max.)	Quantity of water
1:5:10	60 litres
1:4:8	45 litres
1:3:6	34 litres
1:2:4	32 litres

- ii) Generally as broad guidelines, the strength requirements of Nominal mix concrete 1:5:10 shall correspond to grade M5, 1:4:8 shall correspond to grade M7.5, 1:3:6 to grade M10 and 1:2:4 to grade M15 of IS:456.
- iii) If Nominal mix concrete made in accordance with specified proportions does not yield the specified strength of the corresponding grade and fails to satisfy the requirements of "acceptance criteria for concrete" as specified in IS:456. Such concrete shall be treated in the following manner:
- In case the Owner is satisfied that lower strength of concrete is attributed to material and workmanship of the Contractor, then such concrete shall be replaced by concrete of specified strength.
  - In case the Owner is satisfied that lower strength of concrete is not attributable to the Contractor, he may direct in writing to increase the



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cement content to obtain specified strength. Such extra cement shall also be considered for reconciliation purposes. The use of richer mix shall be continued until the Owner instructs otherwise.

- iv) Nominal mix proportion shall not be classified as higher grade proportion either on the ground that the test strengths are higher than the minimum specified or in the case where the Owner directs use of additional cement over the quantity specified for the particular mix proportion to achieve the minimum specified strength.

**1.1.2.2 DESIGN MIX CONCRETE**

- i) Design. Mix Concrete shall be used on all concrete works, except where specified otherwise or specially permitted by the Owner. The mix shall be designed for all grades of concrete (except those specified under Nominal Mix Concrete) such as to obtain the required workability and the characteristic strength not less than the appropriate values given in Table 3 of Technical Specification for Cast-In-Situ Concrete and Allied Work. Using Standard Deviation specified in IS: 10262 corresponding to good quality control, the Minimum value of target strength of design mix of various grades of concrete shall be as per Table 3 of Technical Specification for Cast-In-Situ Concrete and Allied Work.
- ii) However, the Owner may allow, to change the target strength values based on adequate numbers of works test results.

**TABLE 3**

**GRADES OF CONCRETE**

Grade Designation of concrete	Compressive strength of a 15 cm cube at 28 days (N/Sq.m)	
	Preliminary test strength	Characteristic strength on



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	(target strength of trial mix)	works cubes
M 15	20.8	15
M 20	27.6	20
M 25	33.7	25
M 30	39.9	30
M 35	45.4	35

- iii) In proportioning concrete, the quantity of both cement and aggregates shall be determined by mass. However, only in some exceptional cases including concreting in some isolated areas, the Owner may allow the quantity of aggregates to be determined by an equivalent volume basis after the relationship between weight and volume is well established by trials and the same shall be verified frequently. Water shall be either measured by volume in calibrated tanks or weighed. All measuring equipment at site, shall be maintained in a clean and serviceable condition, and their accuracy shall be periodically checked and shall conform to Clause 10.2.2 of IS:456
- iv) To keep the water-cement ratio to the designed value, allowance shall be made for the moisture contents in both fine and coarse aggregates and determination of the same in accordance with IS: 2386 (Part -III) shall be made as frequently as directed by the Owner.
- v) In some of the structures, water-cement ratio shall be restricted even below 0.45. To increase the workability, Plasticiser may have to be used in such cases. Trial mix shall be carried out accordingly.
- vi) With the permission of the Owner, for any of the above mentioned grades of concrete, if the water quantity has to be increased, proportionately cement quantity shall also be increased, to keep the ratio of water to cement same as adopted in Preliminary tests for the corresponding grade of concrete. The extra cement required on account of this shall also be considered for reconciliation purposes.

**1.1.2.3 MIX DESIGN**

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- i) Contractor shall get the initial concrete mix design done from established laboratory such as National Council for Cement and Building Materials, National Test House, Shri Ram Test House, Central Building Research Institute, Roorkee. The mix design shall be done considering various combinations starting with minimum cement contents as per IS:456 for the respective grade, with or without super plasticizer for different slumps suitable for pumping and with varying percentage of fly ash mix with cement viz., 0%, 10%, 15%, and 20% if desired by the Owner.
- ii) IS:10262 shall be followed as general guidance for mix design. Preliminary tests/trial mix, as specified or as required by the Owner, shall be carried out sufficiently ahead of the actual commencement of the work with different grades of concrete made from representative samples of aggregates and cement expected to be used on the works. These tests are to be conducted to arrive at the grading of aggregates, water-cement ratio, workability and the quantity of cement required to give preliminary (target) compressive strengths as specified in Table 3 in Technical Specification for Cast-In-Situ Concrete and Allied Work.
- iii) Minimum cement contents from durability consideration, different exposures and sulphate attack shall be as given in Table-4 of IS:456. In case, higher value is obtained from trial mix from strength consideration, same shall be provided.
- iv) At least four trial mixes are to be made and minimum six test cubes taken for each trial mix noting the slump for each type of mix. The cubes shall then be properly cured and three cubes for each mix shall be tested in a laboratory (approved by the Owner) at 7 days and others at 28 days for obtaining the compressive strength. The test reports shall be submitted to the Owner. The design mix particulars shall indicate with the help of graphs and curves etc. the extent of variation in the grading of aggregates, which can be allowed. While designing mixes, over wet mixes shall be avoided. For chimney, natural draft cooling tower, etc., where assessment of early strength is required, the concrete cubes shall also be tested for early age strength at 1 day and 3 days for establishing the values.
- v) The Contractor shall submit the test reports of mix design to the Owner for his review, indicating design criteria, analysis and proportioning of materials, etc. On the basis of the above test reports, a mix proportion by mass and the water-cement ratio, shall be determined by the Contractor such that concrete prepared with this mix will yield the desired characteristic strength and shall have suitable

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workability. The mix design to be adopted on the works shall be subject to the approval of the Owner.

- vi) The proportions, once decided for different grades of concrete, shall be adhered to, during all concreting operations as long as the quality of the materials does not change. If, however, at any time, the quality of materials being used has changed from those for Preliminary mix design, or there is a change either in the required strength of concrete, or water-cement ratio or workability, the Contractor shall have to make similar trial mixes and perform initial tests to ascertain the revised mix proportions and water-cement ratio to be used for obtaining the desired strength and consistency.
- vii) In the situations, like casting of piles, where the compaction of concrete is not possible by vibration, the method of compacting concrete cubes of Preliminary/trial mixes and work tests shall be in the same manner as the method of compacting concrete at site is proposed.

### **1.1.3 CODES AND STANDARDS**

For applicable codes and standards, refer relevant clause covered under specifications for cast-in-situ concrete and allied works, in addition to the codes and standard mentioned at various places under this division.

### **1.1.4 TECHNICAL REQUIREMENTS - INSTALLATION**

#### **1.1.4.1 WORKABILITY OF CONCRETE**

- i) The workability of concrete shall be checked at frequent intervals. The workability of concrete measured in accordance with IS:1199 for every sample taken for testing shall be recorded with the corresponding cube test result and shall conform to Clause 7.0 of IS:456
- ii) The degree of workability necessary to allow the concrete to be well compacted and to be worked into the corners of formwork and round the reinforcement to give the required surface finish shall depend on the type and nature of the structure and shall be based on experience and tests. The suggested ranges of values of workability for concrete for some placing conditions, measured in accordance with IS: 1199 and as stipulated under Clause 7.0 of IS:456, are given

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below in Table-4 for guidance only. In addition, in some special cases like casting of pile, very high degree of workability (up to 180 mm slump) shall be used.

**TABLE-4**

**LIMITS OF WORKABILITY**

<b>Placing Conditions</b>	<b>Degree of Workability</b>	<b>Slump (mm)</b>
Blinding concrete Shallow sections Pavements using pavers	Very low	0 – 25
Mass Concrete Lightly reinforced sections in slabs, beams, walls, columns, Floors, Hand placed pavements, Canal lining, Strip Footings.	Low	25 – 50
Heavily reinforced sections in slabs, beams, walls, columns,	Medium	50 – 100
Slipform work Pumped concrete	Medium	75 – 100
Trench fill, In-situ piling	High	100 – 150
Tremie concrete	Very High	Clause. 7.1.2 of IS 456

Note:

Notwithstanding, the values given above, the slump to be maintained for work in progress shall be as per directions of the Owner.

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### 1.1.4.2 WATER-CEMENT RATIO

The choice of water-cement ratio in designing a concrete mix will depend on requirement of strength and durability as specified below.

#### a) Strength Requirement

In case of "Design Mix Concrete" the water-cement ratio of such value as to give acceptable test results as per IS: 456, will be selected by trial and error. The values of water-cement ratios for different grade and mix designs will have to be established after conducting sufficiently large number of preliminary tests in the laboratory to the satisfaction of the Engineer. Frequent checks on test will have to be carried out and the water-cement ratios will be revised if the tests produce unsatisfactory results. Notwithstanding anything stated above the Contractor's responsibility to produce satisfactory test results and to bear all the consequences in case of default remains unaltered.

In case of nominal mix concrete, the maximum water-cement ratio for different grades of concrete is specified in Table-5 of IS: 456 and no tests are necessary. The acceptance test criterion for nominal mix concrete shall be as per IS: 456.

#### b) Durability Requirement

Tables 4 & 5 of IS: 456 give the maximum water-cement ratio permissible from the point of view of durability of concrete subjected to adverse exposure to weather, sulphate attacks, and contact with harmful chemicals. Impermeability may also be an important consideration.

Whenever the water-cement ratio dictated by Durability consideration is lower than that required from strength criteria, the former should be adopted.

In general the water cement ratio between 0.4 and 0.45 will be desirable to satisfy the durability requirement and from the consideration of impermeability of concrete. The contractor may propose lower water cement ratio as mentioned above by addition of a suitable plasticizer/super-plasticizer. Trial mix shall be carried out accordingly. However, the contractor has to propose specifically along with field trials in the event of lower cement content if found suitable along with a plasticizer.

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### 1.1.4.3 SIZE OF COARSE AGGREGATES

The maximum size of coarse aggregates for different locations shall be as follows unless otherwise directed by the Engineer.

Very narrow space	12 mm
Reinforced concrete Except foundation	20 mm
Ordinary Plain concrete and Reinforced concrete foundations	40 mm
Mass concrete.	80 mm
Lean concrete	40 mm

Grading of coarse aggregates for a particular size shall conform to relevant I.S. Codes and shall also be such as to produce a dense concrete of the specified proportions, strength and consistency that will work readily into position without segregation.

Coarse aggregate will normally be separated into the following sizes and stacked separately in Properly designed stockpiles.

80 mm to 40 mm, 40 mm to 20 mm and 20 mm to 5 mm. In certain cases it may be necessary to further split the 20 mm to 5 mm fraction into 20 mm to 10 mm and 10 mm to 5 mm fractions.

This separation of aggregates in different size fractions is necessary so that- they may be remixed in the desired proportion to arrive at a correct internal grading to produce the best mix.

### 1.1.4.4 MIXING OF CONCRETE.

- i) All structural concrete mixing shall be done at a single central batching plant, conforming to IS:4925, situated within the area allocated for the Contractor's particular use as shown on the drawing or as directed by the Owner. The plant shall have a mechanically operated mixer of an approved size, capacity and type, capable of ensuring a uniform distribution of the materials throughout the mass and the mass is uniform in colour and consistency. Digitized recording of the material consumed along with the quantity of concrete produced for every shift of eight hours shall be submitted to the Owner.

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- ii) However, for PCC work of M-7.5, M-10 and M-15 Owner may permit the use of independent mechanical mixer with weigh conforming to IS:1791 batching machine
- iii) Water shall not be added into the drum of the mixer, until all the cement and aggregates constituting the batch are already in the drum and dry mixed for at least one minute and are uniformly distributed. Water shall then be added and mixing of each batch shall be continued until there is an uniform distribution of the materials and the mass but in no case shall mixing be done for less than two minutes and for at least 40 revolutions after all the water and materials are in the drum. When absorbent aggregates are-used or when the mix is very dry, the mixing time shall be extended as directed by the Owner. Mixers shall not be loaded above their rated capacity as this prevents thorough mixing. The entire contents of the drum shall be discharged before the ingredients for the next batch are fed into the drum. No partly set or remixed or excessively wet concrete shall be used and it shall be immediately removed from site. Each time if the work stops for more than 30 minutes, 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 owner.
- iv) In exceptional circumstances and/or work in remote areas, hand mixing may be allowed by the Owner, subject to adding 10% extra cement which shall be considered for reconciliation purposes. The mixing shall be carried out on watertight platform and mixing shall be continued till a uniform colour and consistency of the mix is achieved.

**1.1.4.5 CONCRETE CONVEYING**

- i) Concrete shall be handled and conveyed as rapidly as practicable, from the place of mixing to the place of final laying by Transit mixers or by other approved means, before the initial setting of the cement starts. Concrete shall be conveyed in such a way that there is no segregation or loss of any of the ingredients and maintaining the required workability. If segregation occurs during transport, the concrete shall be remixed. During very hot or cold weather, if directed by the Owner, concrete shall be transported in deep containers, which will reduce the rate of water loss, by evaporation in hot weather and heat loss in cold weather, at no extra cost to the Owner.

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- ii) Conveying equipment of concrete shall be watertight, well maintained and thoroughly cleaned. Chutes shall not be used for transport of concrete without the written permission of the Owner. The chute, in case permitted to be used, shall be of such size and design as to ensure practically continuous flow. Slope of the chute shall be so adjusted that the concrete flow without the use of an excessive quantity of water and without segregation of its ingredients. The delivery end of the chute shall be as close as possible to the point of deposit.
- iii) Concrete may be conveyed and placed at location of pour by mechanically operated equipment, e.g. pumps or pneumatic placers with the written permission of the Owner, who shall review the entire scheme for which comprehensive details shall be furnished by the Contractor.

**1.1.4.6 CONCRETE PLACING**

- i) Concrete shall be placed and compacted in its final position before the cement reaches the initial set and normally concrete shall be compacted in its final position immediately after leaving the mixer.
- ii) Where direct placement is not possible, the Contractor shall provide suitable arrangements such as chutes, tremie, elephant trunks, etc. to confine the movement of concrete as directed by the Owner. Concrete shall not be dropped from a height or handled in a manner which may cause segregation.
- iii) If concrete is placed by pumping, the consistency shall be the minimum necessary for such conveyance of concrete. Before commencement of regular pumping, the pipeline shall be lubricated by cement mortar (1:2) and once pumping commences, stoppages shall be avoided.
- iv) Concrete shall not be placed in foundations on soft areas or where there is standing water or debris. Such soft areas shall be removed and filled with 1:4:8/1:3:6 nominal mix concrete, as directed by the Owner.
- v) For rock surfaces, it shall be ensured that the rock is sound. On sloping rock faces, rough steps or benches shall be formed and concrete shall not be placed on a sloping rock surface. Prior to pouring concrete, the rock surface shall be cleaned with a high pressure water and air jet and kept wet for three hours. Also, before placing concrete, water shall be removed from depressions, the rock surface shall

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be dried and a 10mm thick cement sand mortar (1:6) layer shall be placed into all crevices, cracks, depression, etc.

- vi) Rock foundation or construction joint will be kept moist for at least 72 hours prior to placement. Concrete will be placed always against moist surface but never on pools of water. In case the foundation cannot be dewatered completely, special procedure and precaution, as directed by the Engineer will have to be adopted. A layer of mortar of thickness 12 mm of the same or less w/c ratio and the same proportion as that of the concrete being placed or cement slurry will be spread thoroughly on the rock Foundation or construction joint just prior to placement of concrete.
- vii) The placing of concrete shall be a continuous operation with no interruption in excess of 30 minutes between the placing of continuous portions of concrete. Concrete shall be placed in continuous horizontal layers of 150mm or higher thickness as directed by the Owner and thoroughly compacted before placing next layer. The thickness of each layer shall be such that it will be deposited before the previous layer has stiffened. When placing concrete through reinforcing steel, care shall be taken to prevent segregation of the coarse aggregates.
- viii) Approval by the Owner of any of the materials and/or work as required herein shall not relieve the Contractor of his obligation to produce finished concrete in accordance with the drawings and specifications. Slots, openings, holes, pockets etc. shall be provided in the concrete as directed by the Owner.
- ix) Slabs, beams and similar members shall normally be poured in one operation. In special circumstances, with the approval of the Owner, these can be poured in horizontal layers, but it must be ensured that the under layer is not already hardened. Bleeding of under layer, if any, shall be effectively removed. Moulding, throating, drip course, etc. shall be poured as per requirement or as desired by the Owner.
- x) Compaction of concrete shall conform to Clause 13.3 of IS:456. After the concrete has been placed, it shall be spread and thoroughly compacted by approved mechanical vibrators to a maximum subsidence without segregation and thoroughly worked around reinforcement or other embedded fixtures into the correct form and shape. Hand tamping in some cases may be allowed subject to the approval of the Owner. Care must be taken to ensure that the inserts, fixtures,

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reinforcement and formwork are not displaced or disturbed during placing of concrete.

- xi) Whenever vibration has to be applied externally, the design of formwork and the disposition of vibrators shall receive special consideration to ensure efficient compaction and to avoid surface blemishes. Surface vibrators and form attached vibrator shall not be permitted under normal conditions. Their use shall require written approval of the Owner.
- xii) Vibrators shall penetrate both the layer poured and the under layer to ensure good bond and homogeneity and to prevent the formation of cold joints. Immersion vibrators shall not be allowed to come in contact with steel reinforcement after start of initial set. Also, they shall not be allowed to come in contact with forms or finished surfaces.
- xiii) Immersion vibrators shall have a 'no load' frequency, amplitude and acceleration as per IS:2505 depending upon the size of the vibrator. Immersion vibrators shall be operated by experienced personnel. These vibrators shall be immersed not more than 450mm apart and withdrawn when air bubbles cease to come to the surface. Such vibrators shall in no case be used to push concrete inside the forms. Vibrators shall be withdrawn slowly to avoid formation of void inside concrete.
- xiv) No concrete shall be placed in wet weather or on a water covered surface. If there has been any signs of washing of cement or sand, the concrete shall be entirely removed immediately. Suitable precautions shall be taken in advance to guard against possible rains before leaving the fresh concrete unattended.
- xv) Mass concrete shall be poured in lifts not exceeding 1.0 m in height unless otherwise indicated on drawings or as directed by the Owner. Horizontal lift shall not be more than 150cm in thickness, according to provision of IS:457.
- xvi) Formwork and reinforcement shall be approved in writing by the Owner before concrete is placed. Concrete shall be placed only after all preparations for casting have been approved by the Owner and approval given to proceed with the casting in writing on pour card to be maintained by the Contractor for this purpose.
- xvii) Concrete, when deposited, shall have a temperature of not less than 5 °C and not more than 40 °C. When depositing concrete in very hot weather, precautions shall

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be taken so that the temperature of wet concrete does not exceed 40 °Centigrade while placing. This shall be achieved by stacking aggregates under the shade and keeping them moist, using cold water, reducing the time between mixing by sprinkling water, starting curing before concrete dries out, etc. However, before mixing/placing concrete, when the above temperature conditions vary on either side, approval of the Owner shall be obtained for the method of execution.

**1.1.4.7 PROTECTION AND CURING OF CONCRETE**

- i) Newly placed concrete shall be protected by approved means from rain, sun and wind. Concrete placed below ground level, shall be protected from falling earth, during and after placing. Concrete placed in ground containing any deleterious substances, shall be kept free from contact with such ground or with water draining from such grounds, during placing of concrete and for a period of at least three days or as otherwise instructed by the Owner.
- ii) The ground water around newly poured concrete shall be kept down to an approved level by pumping or other approved of drainage. Adequate steps shall be taken to protect immature concrete from damage by debris, excessive loading, vibration, abrasion, mixing with earth or other deleterious materials, etc. that may impair the strength and durability of the concrete.
- iii) Curing shall be done as per Clause 13.5 of IS:456. As soon as the concrete has hardened sufficiently, it shall be kept in a damp or wet condition by ponding or by covering with a layer of sacking, canvas, Hessian or similar materials and kept continuously wet for at least seven days after final setting. This period may be extended, at the discretion of the Owner, upto fourteen days. Curing of vertical surfaces exposed to drying winds shall begin immediately after the concrete has hardened. Concrete slabs and floors shall be cured for the periods mentioned above by flooding with water of minimum 25mm depth.
- iv) Approved curing compounds may be used in lieu of moist curing with the permission of the Owner. However, such permission may be granted only in specific cases. Such compounds shall be applied to all exposed surfaces of the concrete, as soon as possible after the concrete has set.

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- v) Quantity of water applied shall be such as to prevent erosion of placed concrete and retain the surface of concrete in moist condition during the entire curing period.

**1.1.4.8 CONSTRUCTION JOINTS**

- i) Construction joints shall conform to Clause 13.4 of IS : 456. However for water retaining structures, provision of IS : 3370 shall also be followed.
- ii) When work has to be interrupted, the concrete shall be rebated and/or keyed at the joint to such shape and size as may be required by the Owner or as per requirement. All vertical construction joints shall be made with stop boards which are rigidly fixed and slotted to allow for the passage of the reinforcing steel. In the case of water retaining structures, basements, tunnels, etc. water stop of approved material shall be provided, if so specified on the drawings or as directed by the Owner.
- iii) Construction joints shall be located as per technical specification and as per code requirement .. Where it is not described, the joints shall be in accordance with the following guidelines.
- In a column, the joints shall be formed about 75mm below the lowest soffit of the beams framing into it, including haunches, if any. In flat slab construction, the joint shall be 75 mm below the soffit of the column capital.
  - Concrete in a beam shall be placed throughout without a joint. If unavoidable, the joint shall be vertical and within the middle-third of the span. When a beam intersects a girder, the joints in the girder shall be given an offset equal to a distance twice the width of the beam and additional reinforcement provided for shear. The joints shall be vertical throughout the full thickness of the concrete member with suitable shear key as per requirement.
  - A joint in a suspended floor slab shall be vertical at middle of the span and at right angle of the principal reinforcement.

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- Construction joints in equipment foundations shall not be provided without specific concurrence of the Owner.
  - Vertical construction joints in water retaining structures shall not be permitted unless approved by Owner.
  - However, if the Contractor desires any adjustments in the location of construction joints (to suit site conditions) from those shown on drawings or from those explained above, he shall obtain prior approval from the Owner.
- iv) Before fresh concrete is placed, the cement skin of the partially hardened concrete which was poured earlier shall be thoroughly removed and the surface made rough and aggregate exposed, by wire brushing, hacking, water jetting, air jetting or any other method as directed by the Owner. The rough surface shall be thoroughly wetted for about 1/2 hour and shall be dried and coated with 10 to 15 mm thick layer of 1:1 freshly mixed cement and sand slurry. Special care shall be taken to see that the first layer of concrete placed after a construction joint is thoroughly rammed against the existing layer.
- v) In forming a joint, concrete shall not be allowed to slope away to a thin edge. The locations of construction joints shall be planned by the contractor well in advance of pouring and they will have to be approved by the Owner. The Contractor's proposals shall include at least the location of construction joints, the sequence of pouring, formwork details and their stripping times.
- vi) For construction of wall kicker / subsequent pours, the sequence of operation shall be as follows, When the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brushes, care being taken to avoid dislodgement of particles of aggregate. The surface shall be wetted and all free water removed. The surface shall then be coated with neat cement slurry. On this surface, a layer of concrete of 150 mm in thickness/height (minimum) shall first be placed and shall be well rammed against old work, particular attention being paid to corners and close spots. Work, thereafter, shall proceed in the normal way.
- vii) For multiple lift work, a suitable time gap shall be maintained between the setting of the earlier placed concrete and the commencement of next concrete pour. After depositing concrete in columns, piers or walls, a time gap of minimum 4 hours

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and preferably 24 hours shall be maintained before depositing concrete in beams, girders or slabs, supported thereon in order to avoid cracking due to settlement.

**1.1.4.9 WORK IN EXTREME WEATHER CONDITIONS**

During hot weather (atmospheric temperature above 40 degree centigrade) or cold weather (atmospheric temp at 5 degree centigrade and below) the concreting shall be done as per the procedures and precautions set out in IS:7861 (Parts I and II).

**1.1.4.10 CLEANING AND FINISHING OF CONCRETE**

- i) All concrete surfaces shall have an even and clean finish free from honeycombs, air bubbles, fins or other blemishes, unmarred and reasonably smooth. The formwork joint marks on concrete work exposed to view shall be rubbed with Carborundum stone and defects patched up with a paste of cement sand mortar (1:2) and cured. The finish shall be made to the satisfaction of the Owner. Concrete surfaces to be subsequently plastered or where brick work is to be built against item, shall be adequately hacked as soon as the form is stripped off so that proper bond can develop.
- ii) Immediately after removal of forms, the concrete shall be allowed to be inspected and defective areas as pointed out by the Owner shall be removed partially or entirely as directed. Holes, left by form bolts, etc. shall be filled up and made good with cement sand mortar of approved mix. All superficial defects such as honeycombing, rough patches, etc. shall be similarly made good. If the defective area is at a vulnerable location, e.g., at the ends of beams & columns, etc. then it may be necessary to cut out the member completely or in part and reconstruct as directed by the Owner. If epoxies have to be used, the same shall be subjected to the approval of the Owner. Poured concrete affected by faulty formwork shall be removed totally and replaced. If so directed, the Contractor shall have to resort to grouting / shotcreting.
- iii) A smooth finish shall be obtained with the use of forms having smooth and even surfaces and edges. Panels and form linings shall be of uniform size and be as large as practicable and installed with closed joints. Upon removal of forms, the joint marks shall be smoothed off and all finishes, projections etc. removed leaving the surfaces reasonably smooth and unmarred.

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- iv) Where integral cement concrete finish is called for, the surface shall be compacted and then floated and treated with a straight edge and any high and low spots eliminated. The work shall be carried out as per IS:2571.

**1.1.4.11 REPAIRS**

Adequate and sound concrete surfaces, whether formed or unformed, can be obtained by employing a concrete mix of proper design, competent formwork, appropriate methods of handling, placing, and consolidation by experienced workmen.

Unsound concrete resulting from improper mix design, incompetent methods, equipment and formwork, poor workmanship and protection will not be accepted and will have to be dismantled, removed and replaced by sound concrete at the Contractor's cost. The Engineer may, at his sole discretion, allow to retain concrete with minor defects provided the Contractor is able to repair it by approved methods at no extra cost to the Owner, All concrete work shall be inspected by the Contractor immediately after the forms are removed & he will promptly report occurrence of any defects to the Engineer. All repair works will be carried out as per the instructions and in the presence of the Engineer or his representative. Generally, repair work will consist of any or all of the following operations:

- a) Sack rubbing with mortar and stoning with Carborundum stone
- b) Cutting away the defective concrete to the required depth shape
- c) Cleaning of reinforcement & embedment. It may be necessary to provide an anti-corrosive coating on the reinforcement
- d) Roughening by sand blasting or chipping.
- e) Installing additional reinforcement/welded mesh fabric.
- f) Dry packing with stiff mortar.
- g) Plastering, guniting, shotcreting etc
- h) Placing and compacting concrete in the void left by cutting out defective concrete.

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- i) Grouting with cement sand slurry of 1: 1 mix
- j) Repairing with a suitable mortar either cement or resin modified mortars.
- k) Polymer modified patching and adhesive repair & mortar for beams & columns

### **1.1.5 SAMPLING, TESTING AND QUALITY ASSURANCE**

#### **1.1.5.1 GENERAL**

- i) Concrete cubes for works tests shall be cured under normal site conditions. When in the opinion of the Owner, extreme weather conditions prevail, then these may require curing under job conditions.
- ii) For the purposes of statistical analysis, any substandard cube result, which in the opinion of the Owner, is due to improper sampling, Moulding or testing shall be discarded and a dummy result shall be substituted. The value of a dummy result shall be equivalent to the average value of the cubes from the same grade of concrete tested immediately before and after the discarded result. The number of such substandard cubes shall not exceed 5%.
- iii) If the strength of the cubes, for any portion of the concrete work, falls below the compressive strength specified, the Owner shall have the right to order a change in the proportions or the water content for the remaining portion of the structure.
- iv) If the 'strength' of the works cured test cubes falls below the specified strength, the Owner shall have the right to direct the Contractor to follow, provisions for temperature and moisture control during the period of curing as necessary to secure the required strength and may require retest in accordance with the standard method of securing, preparing and testing specimens from hardened concrete for compressive and flexural strengths, or load tests to be made on the portion of the building so affected. All such tests shall be made at the Contractor's expense.
- v) Unacceptable concrete work shall be dismantled by the Contractor and replaced by fresh work, meeting the specification requirements. In the course of dismantling, if any damage is done to the embedded items or adjacent structures,

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the same shall be made good, by the Contractor to the satisfaction of the Owner at no extra cost to the Owner.

- Only as a very special case and that too in non-critical areas, the Owner may accept concrete work which is marginally unacceptable as per the criteria laid down in IS:456.
  - Before placing concrete, the inside of forms shall be checked to ensure that they are clean and thoroughly wetted or adequately treated, so as to prevent absorption of water from the concrete.
- vi) Ultrasonic tests on the foundations of major equipment to ascertain the quality and grade of concreting shall be carried out as per the discretion of the Owner. The Owner shall arrange for the specialised agency for conducting the test at his cost. The Contractor shall provide all the necessary facilities and arrangement for Conducting the test at site in terms of access, scaffolding etc. In case of any defects, the Contractor shall rectify the same as below and as directed by the Owner.
- Cement grout – cement grouting shall be done in structures / foundations where large-scale voids or honeycombing are observed. The cement grout with non-shrink admixture and / or plasticizer shall be used. Water cement ratio needs to be controlled and it shall be preferably less than 0.5. Nipples shall be fixed in the locations where grouting has to be carried out. Cement grout shall be injected at a pressure of 2.5 to 3.0 Kg / Sq.cm.
  - Epoxy grout – epoxy grouting shall be carried out in critical locations from serviceability as well as structural point of view. In addition, this shall be carried out in locations where narrow passage is available for free flow of grout.
- vii) Rebound hammer test shall be carried out for ascertaining the quality of concrete work, as directed by the Owner.
- viii) Test shall be conducted for the water tightness of the liquid retaining structures as per IS:3370 and IS:6494. The details and sequence of tests shall be as given here under:

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- All arrangements, including supply of water for testing purposes, shall be kept ready when the tank is nearing completion.
  - Water supply to the tank shall be in stages of 300 to 450mm height in order to check the water tightness of the tank and location of leakage of various levels.
  - The permissible drop in level in 24 hours shall be 6 mm in case of covered reservoir/tank and 12 mm in the case of open reservoir/tank.
  - The leakage points shall be marked and separately treated during test condition or after dewatering.
  - The reservoir/tank shall be retested for water tightness after rectification, if desired.
- ix) For basement type structures like cables vault, track-hopper, tunnel, neutralizing pit, etc. the contractor shall examine the water tightness against ingress of sub-soil water.
- x) Frequency of sampling and testing including the methods for conducting the tests shall be as given in Table 1 in Technical Specification for Cast-In-Situ Concrete and Allied Work.

**1.1.5.2 SAMPLING OF CONCRETE**

Samples from fresh concrete shall be taken according to IS:1199 and tested as per IS:516.

Normally only compressive test shall be performed but the Owner may require other tests to be performed in accordance with IS:516.

**A) Trial Mixes:**

At least four trial mixes for each grade of concrete shall be made with minimum 6 test cubes for each mix.

**B) Works Tests:**

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The min. frequency of sampling of concrete of each grade shall be according to Clause 15.2.2 of IS:456. However, after getting continuous satisfactory results and in the case of voluminous concrete works, the Owner, may at his discretion reduce the frequency of sampling as follows.

For each grade of concrete and for each 8 hours (shift) of work or part thereof, at least one sample consisting of six specimens shall be taken from each 150 Cu.m. of concrete or part thereof, 3 specimens shall be tested at 7 days and remaining 3 shall be tested at 28 days. However in all cases, the 28 days compressive strength shall alone be the criterion for acceptance or rejection.

- To control the consistency of concrete from every mixing, slump tests and compaction factor testes in accordance with IS:1199 shall be carried out by the Contractor every two hours or as directed by the Owner. Slumps corresponding to the test specimens shall be recorded for reference.
- The strength of sample shall be the average of the strength of three specimens. The individual variation should not be more than  $\pm 15\%$  of the average.

Unless otherwise specified, the tolerance in construction shall be as follows:

Description of Item/ Structural element	Permissible Deviation in mm
The dimensions of concrete as cast when compared with those on the drawings shall be within the tolerance given below:	
Faces of concrete in foundation and structural members against which backfill is placed.	+25 -10
Location of footing (for RCC framed structures only)	+25 -25
Eccentricity of footing	2% of footing width of direction of misplacement but limiting to 0 500 mm.
Top surfaces of slabs and of concrete to receive base plates to be grouted.	+5 -5
Alignment of beams, lintels, columns, walls, slabs and similar elements.	+5 -5



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Description of Item/ Structural element	Permissible Deviation in mm
Cross dimensions of wall, slabs and similar structural elements.	+5 -5
Deviation from specified dimensions of cross-section of columns and beams.	+12 -6
Alignment of holding down bolts without sleeves.	+1.5 -1.5
Alignment of holding down bolts with sleeves.	+5 -5
Level of holding down bolt assemblies.	+10 -10
Embedded parts (in any direction).	+5 -5
Centres of pockets or holes with greatest lateral dimension not exceeding 150mm.	+10 -10
Variation in steps:	
Riser	+1.5 -1.5
Tread	+3.0 -3.0
Plumb	3mm for every metre subject to maximum of 10 mm.

### 1.1.5.3 ACCEPTANCE CRITERIA

The acceptance criteria of concrete shall be in accordance with Clause 16 of IS:456.

### 1.1.5.4 LOAD TEST

If any work is found unacceptable whereupon the Owner requires its removal and reconstruction, the Contractor may request that it should be load tested in accordance with the provision of Clause 17.6 of IS: 456 as given below:

- i) The test load shall be 125 percent of the maximum superimposed load for which the structure or element was designed. This load shall not be applied earlier than 28 days after the effective hardening of concrete. This test load shall be maintained for 24 hours and during the entire duration of the test, struts, strong enough to take the whole superimposed, dead and other loads shall be placed in position, leaving a small gap under the members.

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- ii) The maximum deflection shall be measured after the test load is in position for 24 hours. Thereafter, the test load shall be removed.
- iii) If 24 hours after the removal of the load, the structure does not show a recovery of at least 75 percent of the deflection, registered as in (ii) above, the test shall be repeated after a lapse of 72 hours. The structure shall be considered to have failed to pass the test if the recovery after the second test is not at least 80 percent of the maximum deflection during the second test.
- iv) If the maximum deflection in mm, shown during 24 hours under load, is less than  $40L^2 / D$ , where L is the effective span in metres and D is overall depth of the section in mm, it is not necessary for the recovery to be measured and the recovery provision of the above mentioned clause will not apply.

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**DIVISION - II**

**REINFORCEMENT**

**1.2.1 INTENT**

This Division of the specification deals with reinforcement for all reinforced concrete works and covers the requirement of materials, their properties, storage, handling, furnishing of bar bending schedules and the cleaning, bending, binding and placing of reinforcement with suitable cover blocks. This shall also include the supply of reinforcement, wherever required.

**1.2.2 GENERAL REQUIREMENTS**

The Contractor shall prepare and furnish to the Owner, bar bending schedules for all RCC works for his review and approval. No work shall commence without the approval of bar bending schedules by the Owner in writing.

The Contractor shall have to obtain prior written approval from the Owner, if he desires any adjustments in diameter or spacing of reinforcement. However, the Contractor shall modify the bar bending schedule, when a particular type and size of reinforcement would not be available, with the approval of the Owner.

**1.2.2.1 MATERIALS**

All steel for reinforced concrete works shall be in accordance with Technical Specification for Properties, Storage and Handling of common Building Materials, which shall be deemed to form the part of this specification.

Mild steel and medium tensile steel bars and hard drawn steel wire shall conform to Grade-1 (Fe-250) of IS : 432 (Part-1). All high strength deformed steel bars shall be thermo-mechanically treated Bars and shall conform to grade Fe-415 of IS : 1786. Rolled steel shall conform to grade 'A' of IS: 2062. Hard drawn steel wire fabrics shall conform to IS: 1566.

All bars shall be thoroughly cleaned before being fabricated. Pitted and defective bars shall not be used.

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### **1.2.3 CODES AND STANDARD**

For applicable codes and standards, refer relevant clause covered under specifications for cast-in-situ concrete and allied works, in addition to the codes and standard mentioned at various places under this division.

### **1.2.4 TECHNICAL REQUIREMENTS - INSTALLATION**

#### **1.2.4.1 BENDING AND PLACING**

This shall generally conform to Clause 12 and Clause 26 of IS:456

The Contractor shall prepare Bar Bending Schedules showing clearly the arrangements proposed by the Contractor to match available stock of reinforcing steel, progressively, starting within one week of receipt of approval on corresponding design of RCC structure. As decided by the Engineer, some or all the detailed drawings and schedules will have to be submitted for approval. Approval of such detailed drawings by the Engineer shall not relieve the Contractor of his responsibility for correctness nor of any of his obligations to meet the other requirements of the contract. The contractor for record and distribution shall submit six prints of the final drawings & schedules with one reproducible print.

#### **1.2.4.2 BENDING**

- i) Reinforcing bars, supplied bent or in coils, shall be straightened before these are cut to size. Straightening of bars shall be done in cold and without damaging the bars. This is to be considered as a part of reinforcement bending and fabrication work.
- ii) Unless otherwise specified, reinforcing steel shall be bent in accordance with procedure specified in IS:2502 and/or as approved by the Owner. Bends and shapes shall comply strictly with the dimensions shown on the approved bar bending schedules and they shall be rechecked by the Contractor before bending

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and he shall be entirely responsible for their correctness. Bars correctly bent, shall only be used. Unless specified otherwise or directed by the Owner, the detailing of reinforcement shall be in accordance with IS:5525 and SP:34.

- iii) No reinforcement shall be bent when in position in the work without the approval of the Owner, whether or not it is partially embedded concrete. Where reinforcement bars are bent aside, at construction joints and afterwards bent back into their original positions, care shall be taken to ensure that, at no time, the radius of the bend is less than 4 times the bar diameters for plain mild steel or 6 times the bar diameters for deformed bars. Care shall also be taken while bending back bars, to ensure that the concrete around the bar is not damaged.
- iv) Welding of bars to obtain continuity shall not be allowed, particularly for cold twisted bars, unless specifically approved by the Owner. If welding is approved, the work shall be carried out as per IS:2751 and IS:9417, according to the best practice and as directed by the Owner.

**1.2.4.3 PLACING IN POSITION**

- i) All reinforcement shall be accurately fixed and maintained in position as per detail engineering drawings, by such approved means as steel chairs, and / or concrete spacer blocks as per IS:2502. Bars intended to be in contact at crossing points, shall be securely bound together at all such, joints by two numbers annealed steel wire of 0.9 mm to 1.6 mm size conforming to IS:280 in such a manner that they do not slip over each other at the time of fixing & concreting. The tying of bars shall be in criss cross manner.
- ii) Binders shall tightly embrace the bars with which these are intended to be in contact and shall be securely held. The vertical distance between successive layers of bars shall be maintained by provision of spacer bars. These shall be so spaced that the main bars do not sag perceptively between adjacent spacers.
- iii) Bundled bars shall be provided wherever required, to facilitate concreting. Location of laps and development lengths shall be as indicated on the engineering drawings.
- iv) The placing of reinforcement shall be completed well in advance of concrete pouring. Just prior to concrete pouring, the reinforcement shall be checked by

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the Owner, for accuracy of bar diameters, placement and cleanliness. Necessary corrections as directed by the Owner shall be carried out. Care shall be taken to ensure that projecting ends of ties and other embedded metal do not encroach into the concrete cover. Where concrete blocks are used for ensuring the cover and positioning of reinforcement, these shall be made of mortar 1:2 (1 cement: 2 sand) by volume and cured for at least seven days. The sizes and locations of the concrete blocks shall be approved by the Owner. The 28 days crushing strength of cover blocks shall be at least equal to the specified strength of concrete in which the blocks will be embedded.

- v) Laps and anchorage length of reinforcing bars shall be in accordance with IS:456, unless otherwise specified. If the bars in a lap are not of the same diameter, the smaller diameter will guide the lap length. Laps shall be staggered as far as practicable and as directed by the Owner and not more than 50% of bars shall be lapped at a particular section. Mechanical connections, for splicing reinforcement bars in congested locations may be used by the Contractor, only if approved by the Owner. Reinforcement bars shall not be lapped unless the length required exceeds the maximum available lengths of bars at site.

#### **1.2.4.4 COVER TO REINFORCEMENT**

Unless shown otherwise on the drawings, minimum clear concrete cover for reinforcement including links (exclusive of plaster or other finishes) shall be as follows:

- i) At each end of a reinforcing bar, not less than 25 mm, nor less than twice the bar diameter.
- ii) For a longitudinal reinforcing bar in a column, 40 mm or bar diameter whichever is more. 25 mm cover may be adopted for columns of minimum dimensions 200 mm or under and with longitudinal reinforcement diameter not exceeding 12 mm.
- iii) For longitudinal reinforcing bars in a beam, not less than 25 mm or less than the bar diameter.
- iv) For reinforcement in slabs and walls not exposed to weather or ground, not less than 15 mm nor less than the bar diameter.

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- v) For bottom reinforcement in footing 75 mm, if concrete is laid against the ground or 50 mm if laid on a layer of lean concrete.
- vi) For retaining walls, grade beams, top and sides of footings and similar surfaces exposed to weather or ground 50 mm for bars larger than 16 mm and 40 mm for bars up to 16 mm.
- vii) For concrete members exposed to the action of harmful chemicals, acids, alkalis, atmosphere, sulphurous smoke, sea water etc., the cover shall be as per project requirement.
- viii) For liquid retaining structures cover to reinforcement shall be as specified in relevant clauses of IS: 3370.
- ix) Clear distance between reinforcing bars shall be in accordance with IS:456.
- x) In no case, the cover to reinforcement shall be less than that specified in relevant IS Code provisions.

## **1.2.5 SAMPLING, TESTING AND QUALITY ASSURANCE**

### **1.2.5.1 GENERAL**

Sample bent bars shall be checked to ensure that they conform to the bar bending schedules. Reinforcement in position shall be checked for proper positioning, and rigidity, cover, spacing of bars, placement of chairs and spacers, etc. Also it shall be checked that all bars at crossings are properly tied.

### **1.2.5.2 TOLERANCE**

Tolerance in construction, unless otherwise specified or as approved by the Owner shall be as follows:

<b>Description of item / Structural element in mm. (Max).</b>	<b>Permissible Deviation (Unit : mm)</b>
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Placing of reinforcement		
For effective depth 200 mm or less	+10	-5
For effective depth more than 200 mm	+15	-10
Cover to reinforcement	-5	
Cutting of reinforcement		
When minimum length specified	+75	-
When maximum length specified	-	-50
When maximum or minimum length not specified	+75	-25

Frequency of sampling, testing and acceptance criteria of reinforcement work shall be as given in Table 1 in clause for sampling, testing and quality assurance covered in specification for cast-in-situ concrete and allied works.

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**DIVISION - III**

**FORMWORK AND STAGING**

**1.3.1 INTENT**

This Division of the specification deals with the requirements for the supply, erection, dismantling of formwork and staging required for cast-in-situ concrete works including for making pockets/blockouts.

**1.3.2 GENERAL REQUIREMENTS**

The Contractor shall supply, fabricate, erect and dismantle (after use) all formwork and staging those are required for all activities covered under the specifications. He shall prepare the scheme and submit along with the supporting calculations for approval of the Owner.

**1.3.2.1 MATERIALS**

- i) Materials and accessories for false work (form work) shall conform to Clause no. 6 of IS: 14687.
- ii) Formwork shall compose of steel, best quality wood or non-absorbent type plywood. Timber shall be free from significant knots and shall be of medium grain as far as possible and hard woods shall be used as caps and wedges under or over posts. Timber shall be well seasoned, free from sap, shakes, worm holes, warps or other surface defects and shall have smooth finish.
- iii) Staging, unless specified otherwise, shall generally be of mild steel tubes, steel beams and channels etc. or strong sal ballies 150 mm in diameter or above. Bamboo, small diameter ballies etc., shall not be used unless approved by the Owner in specific cases.

**1.3.2.2 CLASSIFICATION OF FORMWORK**

**A) Ordinary**

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This shall be used in places where ordinary surface finish is required and shall compose of steel and/or approved good quality seasoned wood. The contractor can also use plywood shuttering.

**B) Plywood**

This shall be used in exposed surfaces as per specification or as directed by the Owner where a specially, good finish is required. Such surface shall be formed using approved brand of heavy quality water resists plywood to produce perfectly levelled, uniform and smooth surface. All formwork shall be formed using approved quality BWP type, compreg (densified) plywood with suitable overlay (film faced) and conforming to IS: 3513 Part-III and IS: 4990 to produce a perfectly levelled, uniform and smooth surface. Reuse of such forms may be permitted only after inspection and approval by the Owner, for each such reuse. Any damage to film face shall be caused for rejection. The faces of plywood with suitable overlay shall be dense, smooth and without blisters and patch marks. It shall be of uniform colour. Film face shall have minimum 250 GSM (Grams / Sq.m) coating.

**C) Formwork for shell roofs (Ornamental)**

For this item, the detailed design of formwork shall be submitted by the Contractor to the Owner, well in advance, for his approval. Units of shell forms may be used repeatedly but prior approval shall be required for each repetition. Extra care shall be taken to keep correct levels and profiles.

These shall be used where ornamental and curved surface are required and shall be made of selected best quality well seasoned timbers or of plywood, which can be shaped correctly.

**1.3.3 CODES AND STANDARDS**

For applicable codes and standards, refer relevant clause covered under specifications for cast-in-situ concrete and allied works, in addition to the codes and standard mentioned at various places under this division.

**1.3.4 TECHNICAL REQUIREMENTS – INSTALLATION & REMOVAL**

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### 1.3.4.1 INSTALLATION

- i) Formwork shall conform to Clause 11 of IS:456. Formwork shall consist of all materials required for forming the boxing to pour concrete, including steel/wood/plywood forms, ties, anchors, hangers, inserts, etc. Formwork shall be so constructed that vertical and horizontal adjustments can be made as required. The design and engineering of formwork including staging as well as its erection and dismantling shall be the responsibility of the Contractor.
- ii) The staging shall be true and rigid and thoroughly braced in both directions as well as cross braced, strutted and propped such that it will not deform unduly under weight of concrete and other loads due to men, equipment, etc. Vertical members or props should not be supported on an unpropped lower suspended floor or beam unless it is ensured by the Contractor that the lower floor or beam can safely carry the loads. No propping shall take place until the Owner's approval has been given to the Contractor's scheme submitted along with supporting calculations.
- iii) The forms and staging shall be sufficiently strong to carry without undue deformation, the dead weight of the concrete as a liquid as well as anticipated working loads. Where the concrete is vibrated, the formwork shall be strong enough to withstand the effects of vibration, without appreciable deflection, bulging, distortion or loosening of its components. The joints in the formwork shall be sufficiently tight to prevent any leakage of mortar. The formwork shall be such as to ensure a smooth uniform surface free from honeycombs, air bubbles, bulges, fins and other blemishes. Any blemish or defect found on the surface of the concrete, must be brought to the notice of the Owner immediately and rectified as directed by him.
- iv) To achieve the desired rigidity, ample studs, braces, bolts, spacer blocks, wires, clamps, ties, straps, shores, etc. shall be used to hold the form in proper position without undue distortion. These shall be approved by the Owner but they must in no way impair the strength of concrete or leave stains or marks on the finished surface. Where there are chances of these fixtures being embedded, only mild steel or concrete of adequate strength shall be used. Bolts passing completely through liquid and / or earth retaining walls / slabs, basement walls etc., for the purpose of securing and aligning the formwork, shall not be permitted.

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- v) For exposed interior and exterior concrete surfaces of beams and columns, plywood or other approved forms thoroughly cleaned and tied together with approved corrosion resistant devices shall be used. Rigid care shall be exercised ensuring that all column forms are in plumb / true level, and thoroughly cross braced to keep them in position.
- vi) Bevelled strips 25x25 mm shall be provided to form angles and in corners of columns and beam boxes for chamfering of corners as required or directed by the Owner. Temporary openings for cleaning, inspection and for pouring concrete shall be provided at the base of vertical forms and at other places, where these are necessary and as may be directed by the Owner. The temporary openings shall be so formed that they can be conveniently closed rigidly when required and must not leave any mark on the concrete.
- vii) If it is so desired by the Owner, the Contractor shall prepare and submit, before commencement of the actual work, designs and drawings for formwork and staging and get them approved by the Owner. Formwork shall be so designed and positioned that it can be removed without damage to concrete.
- viii) The Contractor shall maintain necessary camber in centering for all floor slabs and beams in all spanning directions, so as to offset the deflection and assume correct shape. The camber shall have the crown of not less than 8 mm for every 5 metres span unless otherwise shown on the drawings. For cantilever, camber at free end shall be 1 in 100.
- ix) The Contractor shall provide the shuttering for complete stretch of work up to expansion joints for the structures like shell, folded plate etc. and/or as directed by the Owner.

**1.3.4.2 CLEANING AND TREATMENT OF FORMS**

- i) All forms shall be thoroughly cleaned of old concrete, wood shavings, saw dust, dirt and dust sticking to them before these are fixed in position. All rubbish, loose concrete, chipping, shavings, saw dust etc. shall be scrupulously removed from the interior of the forms before concrete is poured. Wire brushes, brooms, compressed air jet and/or water jet etc. shall be kept handy for cleaning, if directed by the Owner.

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- ii) Before formwork is placed in position, the form surfaces, that will be in contact with concrete shall be treated with approved non-staining oil or composition which is insoluble in water and not injurious to concrete. Care shall be taken that the oil or composition does not come in contact with reinforcing steel or stain the concrete surfaces. Burnt oil shall not be allowed to be used specially where the concrete surface will require finishing and/or plaster.

**1.3.4.3 REMOVAL OF FORMS**

- i) This shall generally conform to Clause 11.3 of IS: 456 and 9.5 of IS: 14687
- ii) The Contractor shall begin the removal of formwork only after approval of the Owner. He shall place on record the dates on which the concrete is placed in different parts of the work and the dates of the removal of formwork therefrom. This record shall be checked and countersigned by the Owner. The Contractor shall be responsible for the safe removal of Formwork but the Owner may delay the time of removal if he considers it necessary. Any work showing signs of damage through premature removal of formwork, shall be entirely removed and reconstructed by the Contractor at no extra cost to the Owner.
- iii) The formwork shall be so designed and erected that the forms for slabs and the sides of beams, columns and walls may be removed first, leaving the beam bottoms and their supports in position. Repropping of beams shall not be done except with the approval of the Owner. Formwork for columns and walls at each stage of concreting shall be erected only up to the particular lift of construction. Wedges, spacer bolts, clamps or other suitable means shall be provided to allow accurate adjustment of the formwork and to allow it to be removed gradually without jerking the concrete.
- iv) Forms of various types of structural components shall, under normal circumstances, not be removed before the minimum periods specified in Clause. 11.3 of IS: 456, which shall also be subject to the approval of the Owner. However, in any case formwork shall not be struck until the concrete has reached strength, at least twice that of the stress to which the concrete may be subjected to at the time of removal of forms.

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- v) In normal circumstances and where ordinary Portland cement is used, forms may generally be removed after the expiry of the following periods, according to Clause 11.3 of IS:456 and 9.5 of IS: 14687.
- |    |  |             |
|----|--|-------------|
| a) | Walls, columns and vertical faces of all structural members as directed by the Owner | 1 to 2 days |
| b) | Slabs (Props left under)   | 3 days      |
| c) | Beam soffit (props left under)   | 7 days      |
| d) | Removal of props under slabs   |             |
|    | Spanning upto 4.5 m  | 7 days      |
|    | Spanning over 4.5 m  | 14 days     |
| e) | Removal of props under Beams   |             |
|    | Spanning upto 6 m  | 14 days     |
|    | Spanning over 6 m  | 21 days     |
| f) | Cantilever Slabs   | 14 days     |
- vi) The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.
- vii) Where the shape of the element is such that the formwork has re-entrant angles, the formwork shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking occurring due to the restraint imposed.
- viii) In case of cantilever slabs, the removal of forms shall begin from the outer edge and proceed towards the support, where as in the case of slabs supported on two/ four sides, the removal of forms shall begin from centre to supports.

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- ix) The formwork shall be so made as to produce a finished concrete, true to shape, lines, plumb and to dimensions as per requirement. The Owner may call for finished work at any time to set standards of workmanship. Once approved, these will become the accepted Sample.
- x) In case PPC/PSC is used instead of OPC, the removal of shuttering/support shall be after 50% more time from that being applied for OPC, unless otherwise permitted by the Owner. For concrete temperature above 40 °C, stripping time shall be increased.
- xi) In case of special structures, such as shells, folded plates, etc., the sequence of removal of forms shall be as per detail engineering drawings or as directed by the Owner.

#### **1.3.4.4 REUSE OF FORMS**

Before reuse, all forms shall be thoroughly scraped, cleaned, all nails and adhering substances removed, holes and leaks satisfactorily plugged, joints examined and where necessary repaired and inside surfaces treated as specified herein before. Formwork shall not be used/re-used, if declared unfit or unserviceable by the Owner.

#### **1.3.5 SAMPLING, TESTING AND QUALITY ASSURANCE**

##### **1.3.5.1 GENERAL**

Staging shall be checked for its soundness as a whole and for adequacy of the joints and its foundations. Formwork joints shall be inspected for soundness of connections. All joints shall be either vertical or horizontal and shall be such as to avoid loss of liquid through the formwork.

The formwork shall be so made as to produce a finished concrete, true to shape, lines, levels, plumb and dimensions as required, subject to the following tolerances unless otherwise specified in this specification or directed by the Engineer-in-Charge.

For -	a) Sectional dimension	±5mm
	b) Plumb	1 in 1000 of height
	c) Levels	± 3 mm before any deflection has taken place

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The tolerance given above are specified for local aberrations in the finished concrete surface & should not be taken as tolerances for the entire structure taken as a whole or for the setting and alignment of formwork, which should be as accurate as possible to the entire satisfaction of the Engineer. Any error, within the above tolerance limits or any other as may be specially set up by the Engineer, if noticed in any lift of the structure after stripping of forms, shall be corrected in the subsequent work to bring back the surface of the structure to its true alignment.

In case of inclined surfaces like track hopper wall, folded plates etc., the deviation in the alignment of inclined surfaces, shall not exceed 3 mm with reference to the theoretical alignment, for a length of 1000 mm measured vertically, subject to a maximum of 10 mm.

In addition to above, requirement of Clause 11.3 of IS: 456 shall be complied with, which shall be the final acceptance criteria of concrete work.

Frequency of sampling and testing of work, shall be as given in Table 1 in relevant Clause of Specification for cast-in-situ concrete and allied work.

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**DIVISION - IV**

**EMBEDDED PARTS**

**1.4.1 INTENT**

This Division of specification deals with the supply, fabrication (where called for) and/or erection of embedded steel parts and PVC pipes including laying of rails and anchor fasteners.

**1.4.2 GENERAL REQUIREMENTS**

- i) Embedded steel parts shall be either furnished by the Owner for transportation & erection by the Contractor or supplied, fabricated and erected by the Contractor as stipulated. If supplied by the Owner, these parts shall be furnished anywhere within the project area and the Contractor shall transport and install the same in the work site.
- ii) Embedded steel parts supplied by Owner and erected by the Contractor shall include items such as, but not limited to, foundation grillages, anchor bolts, pipe sleeves, equipment mounting-plates, steel pieces properly welded with necessary lugs, as per requirement, auxiliary framing for equipment supports, pegstay plugs for door and window frames, dowel bars for concrete work, miscellaneous frames, etc.
- iii) Embedded steel parts supplied, fabricated/erected by the Contractor shall include items such as, but not limited to as listed below.
  - Inserts, hangers, anchors, frame around openings, manhole covers, frames, floor clips, sleeves conduits and pipes.
  - Anchor bolts and plates for machinery, equipment and for structural steel work.
  - Steel structural to be left embedded for future extension, special connection etc

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- Dowel bars, etc. for concrete work falling under the scope of other contractors.
  - Lugs or plugs for door and window frames occurring in concrete work.
  - Flashing and jointing in concrete work.
  - Any miscellaneous embedment and fixture as may be required.
- iv) Correct location and alignment, as per drawings/instruction of all these embedded items shall be entirely the responsibility of the Contractor.
- v) Cold work deformed steel bars shall not be used for lugs.

#### **1.4.2.1 MATERIALS**

The materials shall be in accordance with the relevant clauses of Technical Specification for 'Properties, Storage and Handling of Common Building Materials, which shall be deemed to form a part of this specification.

Mild steel pipes shall conform to IS:1161. Unless otherwise specified, medium class pipes shall be provided.

PVC pipes shall conform to IS- 4985. Minimum pressure rating shall be 2Kgf/ cm<sup>2</sup>

Rolled steel and structural steel shall conform to IS:2062.

#### **1.4.3 CODES AND STANDARDS**

For applicable codes and standards, refer relevant clause covered under specifications for cast-in-situ concrete and allied works, in addition to the codes and standard mentioned at various places under this division.

#### **1.4.4 TECHNICAL REQUIREMENTS - INSTALLATION**

- i) The Contractor shall fabricate, transport to site and erect accurately in position all embedded steel parts either by welding, bolting or any other means as approved by the Owner. Exposed surfaces of embedded parts other than holding down bolts, unless otherwise stated, are to be painted with two coats of approved

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anticorrosive paint (as per IS:2074) and/or bituminous paint as directed. The threads of holding down bolts shall be greased and protected with waterproof tape.

- ii) During erection, the Contractor shall provide necessary strong temporary bracing and supports to ensure proper installation of the embedded parts which shall be erected at the true location as per requirement and these shall be in plumb and level (unless otherwise shown on drawings). The Contractor shall furnish the Owner with fabrication and assembly drawings prepared for embedded steel parts showing the erection procedure, for major items, wherever necessary.
- iii) Fabrication & erection shall be carried out as per IS: 800. Welding rods & site/field welding shall conform to IS: 816 and IS: 9595. IS: 7634 (part-III) shall be followed for PVC pipe works.

**1.4.4.1 RAILWAY TRACK**

Rail tracks, as directed by the Owner, Shall be erected by the Contractor under supervision of a specialized agency appointed by owner. It shall be ensured by the contractor that the rails are installed true to line, level and gauge. The rail along with the fish plates, wherever required, shall be supplied by the owner.

**1.4.4.2 LAYING OF RAIL**

Laying of rail using rails of 52 kg/m (minimum) in Transformer yard, as per the direction of the Owner or as shown in the drawings.

**1.4.4.3 ANCHOR FASTENERS**

- i) Expansion fasteners shall be used for fixing of steel members, embedments, equipment mounting frames and similar other parts subsequent to concrete work. Fasteners shall be of appropriate type, size and capacity as per manufacturer's specification, and shall be installed by drilling holes of appropriate size in the concrete.

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- ii) The anchor fasteners shall be of two types viz. Medium duty for carrying tensile load (uplift) upto 1.0 MT per fastener and heavy duty for carrying tensile load of more than 1.0 MT and upto 5.0 MT per fastener.
- iii) The safe tensile load carrying capacity of the anchors shall be arrived by providing the minimum factor of safety of 2.5 on the characteristic load of the anchor. Minimum size of anchors shall be M8.
- iv) All anchors shall be from established and approved manufacturers.
- v) Anchors shall be fixed in position as recommended by the manufacturer and as approved by the Owner.
- vi) Anchor fasteners can be of mechanical bonding such as keying, friction, combined friction – Keying or chemical bonding.
- vii) Capacity of the anchors shall be established after considering the effect of concrete grade, embedded depth, concrete thickness, anchor spacing and edge distance from the concrete edge.
- viii) The selection for the particular type of bonding for the anchors shall be made after considering the concrete grade, available embedment depth, load to be transferred, space available for installing anchors.
- ix) Bonding of anchors can be either mechanical and / or chemical
- The mechanical bonding anchors are torque controlled anchors made from carbon steel of grade 8.8 as per IS: 1367 Part III. Anchors in bolt as well as nuts version are acceptable. The bolt version anchors consists of bolt, washer, sleeves, plastic section, expansion sleeves and a cone. Nuts version anchors consists of nuts, threaded rod, washer, sleeve, plastic section, expansion sleeve and a cone. All steel components of anchors shall be electro galvanized to minimum 5 micron coating thickness. The plastic section shall be of Polyacetal Derlin 100 or equivalent.
  - Chemical bonding anchors shall consist of foil capsule and threaded rod. The foil capsule shall contain the resin and hardener. The threaded rod shall have chiseled tip. The anchors shall be tested for its behaviour under fire as

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per heating curve ISO: 834 for upto 120 minutes and furnish the test result. Anchors of size M\* to M24 shall conform to grade 5.8 and M27 to M39 anchors shall conform to 8.8 grade. The grades are as per IS: 1367 Part – III. All steel components of the anchors shall be electro galvanized to minimum 5 micron coating thickness.

- x) These anchors shall comprise of studs, nuts, washers and expansion sleeves. The one end of the stud shall have thread and the other end shall have cold formed conical head. All steel components of the anchors shall be electro galvanized to minimum 5 micron coating thickness. The expansion sleeve shall preferably be of stainless steel of SS316. The anchors shall conform to minimum grade of 5.8 as per IS: 1367.

#### **1.4.5 SAMPLING, TESTING AND QUALITY ASSURANCE**

Frequency of sampling, testing and acceptance criteria shall be as per relevant clause for Technical Specifications for Cast-in-situ Concrete and Allied Work.

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**DIVISION - V**

**FOUNDATION BOLT ASSEMBLY**

**1.5.1 INTENT**

This Division of the specification deals with the requirements of supply, fabrication and erection of foundation bolt assembly etc.

**1.5.2 GENERAL REQUIREMENTS**

Supply, fabrication, erection and installation of Foundation bolt assembly shall comprise of foundation bolts, stiffener plates, washers, nuts, lock nuts, pipe sleeves, etc.

**1.5.2.1 MATERIALS**

- i) Foundation bolts shall generally conform to IS:5624. Mild steel bars used for the fabrication of bolt assembly shall conform to grade- 1 of IS:432, IS:226, IS: 2062 or any other material including high carbon/high tensile steel as specified.
- ii) Hexagonal nuts and lock nuts shall conform to IS:1363 & IS:1364 upto M 36 dia and IS: 3138 for M 42 to M 150 dia.
- iii) Flat plain washers shall be of mild steel and punched/machined type conforming to IS: 5369.
- iv) Steel pipe sleeves shall conform to Medium class of IS: 1161.

**1.5.3 CODES AND STANDARDS**

For applicable codes and standards, refer relevant clause covered under specifications for cast-in-situ concrete and allied works, in addition to the codes and standard mentioned at various places under this division.

**1.5.4 TECHNICAL REQUIREMENTS - INSTALLATION**

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- i) The fabrication and erection of bolt assemblies shall include threading, cutting, grinding, drilling, welding, etc. complete. All bolts, bolt assemblies, etc. shall be fabricated by the Contractor to the correct dimensions and shapes as per requirement. The bolts shall have coarse pitch screw thread in the diameter range 8 to 64 mm and 6 mm pitch screw for diameter > 64 mm as per IS: 4218.
- ii) For fabrication of any particular size of bolt indicated on the drawing, the diameters of the threaded portion of the bolt shall be considered as the diameter of the bolt.
- iii) Fabrication & erection shall be carried out as per IS:800. Welding shall conform: to IS:816 and IS:9595.
- iv) Every bolt shall be provided with a steel washer, under the nut. The washer shall be flat and min outside inscribed circle have a diameter 2.50 times that of the bolt and of suitable thickness. All nuts shall be of steel with well formed hexagonal heads, unless specified otherwise, forged from solid metal and shall be dipped in hot boiled linseed oil as soon as these are made. The nuts shall fit good on the bolts. Tapered washer and lock nut shall be provided as per requirement.
- v) During erection, the Contractor shall provide necessary template, temporary bracing, supports etc. to ensure proper positioning of the assemblies and holding them firmly until they are cast/grouted and the pour has set. All materials shall be erected in plumb and in level (unless otherwise specified) and at true locations as per requirement. Threads shall be protected by using PVC tape.

### **1.5.5 SAMPLING, TESTING AND QUALITY ASSURANCE**

For sampling, testing and quality assurance, refer relevant clause under Technical Specifications for Cast-in-situ Concrete and Allied Work.

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**DIVISION - VI**

**SHOTCRETING**

**1.6.1 INTENT**

This Division of the specification deals with the requirements of furnishing and placement of shotcreting.

**1.6.2 GENERAL REQUIREMENTS**

Generally, shotcreting shall be done in accordance with IS:9012

Reinforcement for shotcreting shall be as detailed below, unless specified otherwise.

- i) Reinforcement in one direction consisting of 6 mm M.S. bars at 750 mm c/c shall be connected to the lugs or fastening of the wire fabric. This shall be used in case of 50mm or above thick shotcreting.
- ii) Wire fabric conforming to IS:1566 shall be used as reinforcement and shall consist of wire, 3 mm diameter, spaced 50 mm both ways and shall be electrically cross welded. Wire fabric shall be securely tied to 6 mm bars for 50 mm (min) thickness. Adjacent sheet of wire fabric shall be lapped at least 100 mm and tied.
- iii) Clear cover to reinforcement mesh shall not be less than 15 mm.
- iv) This work shall be executed only by experienced operators, approved by the Owner.
- v) Minimum thickness of shotcreting shall be 50 mm for abrasion resistant and 25 mm for ordinary surface protection work.

**1.6.2.1 MATERIALS**

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Generally, the materials shall be in accordance with the relevant clauses of Technical Specification for properties, Storage and Handling of common Building Materials, which shall be deemed to form a part of this Specification.

- i) Fine aggregate shall consist of natural sand or crushed stone from a known source and shall be strong, hard, coarse, sharp, chemically inert, clean and free from any coating. It shall be free from clay, coal or coal residue, organic or any other impurities that may impair the strength or durability of the concrete and shall conform to IS:383.
- ii) Fine aggregate (sand) shall be well graded and particles shall range in size within the following limits. The Owner, may approve the use of any other grading as per the requirements of IS: 9012.

<b>IS Sieve Designation</b>	<b>Percentage passing by Weight</b>
10 mm	100
4.75 mm	90-100
2.36 mm	60-95
1.18 mm	45-80
600 microns	35-60
300 microns	8-30
150 microns	0-10

- iii) The fineness Modulus shall be preferably between 2.8 & 3.2. Any other value can be used, with prior approval of the Owner.

Water shall be clean & free from deleterious matter and shall have same properties, stipulated for use in concrete work.

Set accelerating and water proofing shotcreting admixtures of approved make shall be used wherever required.

### **1.6.3 CODES AND STANDARDS**

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For applicable codes and standards, refer relevant clause covered under specifications for cast-in-situ concrete and allied works, in addition to the codes and standard mentioned at various places under this division.

**1.6.4 TECHNICAL REQUIREMENT - INSTALLATION**

- i) After the placement of reinforcement and/or welded mesh and not more than six hours prior to the application of shotcrete, the surface shall be thoroughly cleaned of all loose materials and dirt. The Contractor shall properly prepare the surfaces, reinforcement and/or welded mesh to receive the shotcrete. Cleaned surfaces shall be wetted not more than one hour prior to shotcreting.
- ii) The mix as placed on surface shall be one part cement to three parts approved sand by volume. Cement and sand shall be dry mixed with no water added after mixing and before using in the gun. The quantity of water when added, shall be only that which is sufficient to hydrate the cement. For average atmospheric conditions, the water cement ratio for shotcrete in place shall be between 0.35 and 0.5. Suitable admixture shall be used wherever required.
- iii) A uniform pressure of not less than 2.5 kgf/cm<sup>2</sup> at the nozzle shall be maintained. Necessary adjustments shall be made to ensure this pressure, taking into account the length of hose and height of the place to be shotcreted, above location of the machine.
- iv) The application shall proceed in an upward direction. Beams, stiffeners and intermediate walls, if any, shall be wrapped with wire fabric and completely covered with shotcreting. All rebound shall be removed from the area of application as the work progresses and such rebound material shall not be reused.
- v) As soon as the freshly shotcreted surface shows the first dry patches, a fine spray of water shall be applied to keep it moist. After the surface has hardened, it shall be kept continuously moist for minimum seven days. If there is extreme heat, especially when accompanied by hot winds, the shotcreted surface, immediately upon completion, shall be covered with burlap or similar covering, which must be kept continuously moist for 14 days after shotcreting. The temperature of the lining shall not be permitted to exceed 38 Degrees Centigrade during placing and curing.

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- vi) Shotcreting for hoppers, bunkers and any other structure shall be done as per requirement.
- vii) For cement reconciliation, the cement required shall be worked out on the basis of the actual volume of finished shotcrete. Additional permissible wastage of cement shall be governed by General Conditions of Contract. In absence of any stipulation in General Conditions of Contract, this value shall be limited to 30%.

**1.6.5 SAMPLING, TESTING AND QUALITY ASSURANCE**

Frequency of sampling, testing and acceptance criteria shall be as per relevant Divisions of this specification.

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**DIVISION - VII**

**GROUTING**

**1.7.1 INTENT**

This Division of the specification deals with the requirements of furnishing and placement of grout in blockouts and foundation bolt holes and underpinning of base plates. Grouting of machine bases is not covered in this specification.

**1.7.2 GENERAL REQUIREMENTS**

- i) The space between the top surface of the foundation and the underside of the base plate shall be filled with appropriate grout.
- ii) Crushing strength of grout shall be one grade higher than the foundation concrete. Minimum crushing strength shall be 25N/sq.mm. unless otherwise specified.
- iii) The contact area between the grout and base plate shall not be less than 80%.

**1.7.2.1 MATERIALS**

- i) Cement shall be Ordinary Portland Cement, slag cement or Pozzolana Portland Cement conforming to IS:269 (33 Grade), IS: 8112 (43 Grade), IS: 455 and IS: 1489 respectively.
- ii) Sand shall be clean and well graded conforming to IS 383. For flowable grout, sand conforming to zone-4 grade shall be used. Coarse aggregate wherever used shall also conform to IS:383.
- iii) Clean potable water as recommended for concrete mix shall be used.

**1.7.2.2 ADMIXTURE**

Non-shrink grouting admixtures of approved make shall be used.

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Plasticizer conforming to IS : 9103 shall be used to increase the workability, wherever required.

### **1.7.3 CODES AND STANDARDS**

For applicable codes and standards, refer relevant clause covered under specifications for cast-in-situ concrete and allied works, in addition to the codes and standard mentioned at various places under this division.

### **1.7.4 TECHNICAL REQUIREMENTS - INSTALLATION**

#### **1.7.4.1 TYPE OF MIX.**

There shall generally be following three types grout mix:

- i) Ready mixed non-shrink cementitious grout
- ii) Cement-Sand Grout: The proportion of cement to sand shall generally be 1:1, unless otherwise specified.
- iii) Cement Aggregate Grout: The approximate proportions of cement, sand and coarse aggregate shall be 1 :1.25:2, with a maximum size of aggregate as 10 mm. This mix shall generally be used for grout thickness above 40 mm for dry pack application.

#### **1.7.4.2 MIXING**

Depending upon the case of placement and method of application, there shall be following three grout consistencies.

#### **1.7.4.3 FLUID MIX:**

Water-cement ratio shall be 0.6(max.). Plasticizer may be added to increase workability, wherever required. This grout mix shall be suitable for application with low pressure grouting equipment or self flowing and suitable for grouting of pockets/blackouts, etc.

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**1.7.4.4 PLASTIC MIX:**

Water-Cement ratio shall be about 0.5. This grout mix shall be suitable for application with trowel or rod.

**1.7.4.5 STIFF MIX:**

Water-cement ratio shall generally be 0.4. This grout mix shall be suitable for dry-pack application. The consistency should allow pressurising into firm hard ball without cracking.

**1.7.4.6 PLACING**

- i) The blockouts, bolt holes etc. which have to be grouted, shall be cleaned thoroughly by use of compressed air just prior to taking up the grouting operations.
- ii) Surface to be grouted shall be kept moist for at least 24 hours in advance.
- iii) Cement, sand, aggregate, and non-shrink admixture of approved quality and proven make shall be first blended thoroughly in the required proportion as per manufacturers specifications. Grout shall then be prepared by mixing this admixture with water. Any grout which has been mixed for a period longer than half an hour shall not be used on the work.
- iv) Immediately after preparation, a grout of suitable mix shall be poured into the blockouts, pockets and bolt holes either from the sides or through the holes provided for this purpose in the base plate, by using special equipment for pressure grouting. It shall be ensured by rodding and by tapping of bolts that the blockouts is completely filled without leaving any voids. The pouring shall cease as soon as each hole is filled and any excess grout found on the surface of the concrete foundation shall be completely removed and the surface dried.
- v) The space between the top surface of the foundation concrete and the underside of the baseplate shall be filled with appropriate grout type. Grouting, once commenced, shall be done continuously. Grout shall be worked from one end to

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the other (to prevent air entrapment) and until the grout oozes out through the grout holes provided in the base plates.

- vi) In case of stiff mix, the space between the top surface of foundation concrete and the underside of the base plate shall be dry packed by firmly pressing or ramming into place against fixed supports.
- vii) When it is clear that the centre of base has been properly filled, the grout outside the base plate shall be briefly rammed to ensure compaction below the edges. Shims provided for the alignment of column bases shall be positioned at the edges of the base to permit subsequent removal, which shall take place not less than 7 days after the grouting has been executed. The resulting cavities shall be made good with the same grade of grout as has been used for grouting under the rest of the base plate.
- viii) The work shall be cured for a period of at least 7 days commencing 24 hours after the completion of the grouting. The curing shall be done by covering the surfaces with wet gunny bags and flooding.

### **1.7.5 SAMPLING, TESTING AND QUALITY ASSURANCE**

The sampling, testing and quality assurance shall be as per the stipulations indicated in relevant divisions of this specification.

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**DIVISION - VIII**

**ENCASEMENT OF STEEL STRUCTURES / ELEMENTS**

**1.8.1 INTENT**

This Division of specification deals with the requirement for encasement of steel work in concrete with necessary formwork, placing, finishing and curing, complete as per drawings and specifications.

**1.8.2 GENERAL REQUIREMENTS**

- i) All concrete work, reinforcement, formwork & staging work shall be done as per stipulations of Division I, II and III of this specification.
- ii) The reinforcement to be provided for encasement of steel elements shall be mild steel bars or in the form of wire netting. Such reinforcement shall be kept 20 mm away from the steel member and held securely to it.
- iii) The minimum grade of concrete to be used for encasing shall be M-20 unless specified. The aggregate to be used in concrete shall be 12.5 mm maximum size unless specified otherwise. In case of box type steel sections, encasement shall be done with cement sand mortar (1:4) with thickness of 50 mm over 0.9mm size wire netting conforming to IS:3150, or as per requirement.
- iv) In the case of encasement of beams with concrete if the gap between the edge of the shuttering and flange is hardly sufficient for placing the concrete, the workability of the concrete shall be increased suitably by increasing the water cement ratio.
- v) Minimum cover for concrete encasement shall be 50mm.

**1.8.2.1 MATERIALS**

The materials shall be in accordance with the relevant clauses of Technical Specification for Properties, Storage and handling of common Building Materials

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which shall be deemed to form the part of this specification. Hexagonal wire netting shall be 0.9 mm dia and 19 mm aperture size, conforming to IS: 3150.

**1.8.3 CODES AND STANDARDS**

For applicable codes and standards, refer relevant clause covered under specifications for cast-in-situ concrete and allied works, in addition to the codes and standard mentioned at various places under this division.

**1.8.4 TECHNICAL REQUIREMENTS – INSTALLATION**

The technical requirements for installation and laying of all necessary concrete works, reinforcements, formwork and staging shall be as per the stipulation indicated in relevant Divisions of this specification for Cast-in-Situ and Allied Work.

**1.8.5 SAMPLING, TESTING AND QUALITY ASSURANCE**

The sampling, testing and quality assurance of all necessary concrete works, reinforcements, formwork and staging shall be as per the stipulation indicated in relevant divisions of this specification..

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**DIVISION - IX**

**JOINTS IN CONCRETE**

**1.9.1 INTENT**

This Division of the specification deals with the requirement of furnishing & installing of joints in concrete including joint filler materials, sealing compound, cement slurry modified with acrylic polymer, water bars, resilient pads type vibration damping material in and around the sides of concrete works, etc.

**1.9.2 GENERAL REQUIREMENTS**

Details of joints shall be as approved by Owner or as per approved drawings. Where necessary or / and specified, joints shall be made water tight by use of water stops and / or joint filler, sealing compound etc.

**1.9.2.1 CLASSIFICATION OF JOINTS**

From the point of view of utility, the joints as provided may be classified as below:

**A) Construction Joints**

Construction joints are produced by placing fresh concrete against surface of hardened concrete. Construction joints are generally, but not necessarily, vertical or horizontal. Requirements of construction joints shall be as per Clause 13.4 of IS: 456.

Where the location 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 lowest soffit of the beam framing into it.
- 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 of the span.

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- c) A joint in a suspended floor slab shall be vertical and at the middle of the span and at right angles to the principal reinforcement.
- d) Feather-edges in concrete shall be avoided while forming a joint.
- e) A construction joint should preferably be placed in a low-stress zone and at right angles to the direction of the principal stress.
- f) In case the Contractor proposes to have a construction joint anywhere to facilitate his work, the proposal should be submitted well in advance to the Engineer for study and approval without which no construction joint will be allowed.

**B) Contraction Joints**

These are provided to eliminate tensile stresses due to shrinkage and are commonly used where temperature variations are small and where there is no likelihood of expansion, such as spaces below water and earth levels & unexposed to atmosphere. At contraction joints, the reinforcement is discontinued and bond is not allowed to develop between the joint faces, thereby introducing a structural discontinuity. A contraction joint also serves as a construction joint so far as break in the pouring of concrete is concerned.

**C) Expansion Joints**

These are provided either to completely eliminate or to significantly reduce compressive stresses in concrete that would otherwise result from thermal expansion and might crush, buckle or crack part of the structure. Expansion joints serve the purpose of contraction and construction joints.

**D) Control Joints**

At places where cracking is inevitable, places of weakness are introduced by the provision of control joints so that the cracking takes place along these joints instead of allowing it to develop in a haphazard manner.

**E) Separation Joints**

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The places where the expansion of the structure is not expected but they are required to be kept structurally separate so that stresses, vibrations etc. are not transferred, a separation joint should be provided. Like expansion joint, a gap is provided in separation joint also, but this is not expected to be used up by the expansion of members. In case, no gap is required, the separation joint can be obtained by using an approved alkathene sheet stuck on the surface against which concrete shall be placed.

**F) Settlement Joints**

Structures, which are likely to settle with respect to the adjacent structure shall be separated by a settlement joint so that the adverse effects of differential settlement are obviated. It is like an expansion joint but with a different sealing arrangement.

**G) Cold Joint**

An advancing face of a concrete pour, which could not be covered by fresh concrete before expiry of initial setting time (due to an unscheduled stoppage or delay on account of breakdown in plant, inclement weather, low rate of placement or any other reason), is called a cold joint. The Contractor should always remain vigilant to avoid cold joints.

If, however, a cold joint is formed due to unavoidable reasons, the following procedure shall be adopted for treating it:

- i) If the concrete is so green that it can be removed manually and. if vibrators can penetrate the surface without much effort, fresh concrete can be placed directly against the old surface. The old concrete should be covered by fresh concrete as quickly as possible and the joint thoroughly and systematically vibrated.
- ii) In case concrete has hardened a bit more than (a) but can still be easily removed by a light hand pick, the surface will be raked thoroughly and the loose concrete removed completely without disturbing the rest of the concrete in depth. A rich mortar layer 12 mm in thickness, will be placed on the cold joint fresh concrete shall be placed on the mortar layer and the joint will be

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thoroughly and systematically vibrated penetrating the vibrator deep into the old layer of concrete.

- iii) In case the concrete at the joint has become so stiff that it cannot be remoulded and mortar or slurry does not raise in spite of extensive vibration, the joint, will be left to harden for at least 12 - 24 hrs. It will then be treated as a regular construction joint, after cutting the concrete to required shape and preparing the surface as described under relevant clause.

### 1.9.2.2 MATERIALS

#### A) Joint Filler:

- i) Bitumen Impregnated Fibre Board

The bitumen impregnated fibre board, a preformed material shall be used as joint filler which shall fill space between the concrete surfaces at the joints. The minimum thickness of board shall be 12mm and the material shall conform to IS: 1838.

- ii) Expanded Polystyrene Board

The expanded polystyrene slab shall be of fire retarding grade (type-2) conforming to IS: 4671. Density of material shall not be less than 25kg/cu.m. The nominal size of each board and thickness shall be as specified in the schedule of items.

#### B) Water Stops

- i) Water stops shall be provided at the 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.

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ii) The water stops shall be metallic like Copper, or non-metallic like rubber, PVC, etc. The material is to be procured from reputed manufacturers having proven records of satisfactory supply of Water Stops of similar make and shape for other jobs. Only PVC water stop shall be used, unless, otherwise, specifically approved by the Owner.

iii) Non-metallic Water Stop

The water stops shall be normally of rubber or PVC and can be of shape having any combination of the following features:

- Plain
- Central Bulb
- Dumb-bell or flattened ends
- Ribbed and Corrugated Wings
- V-shaped.
- Kicker type (Externally placed)

Water bars shall generally meet the stipulations of IS:12200. The minimum thickness of PVC Water Stops shall be 5 mm and the minimum width 225 mm unless otherwise specified in the schedule of items. However, for some non critical areas 150mm wide and 5 mm thick water stop can be used. The actual size and shape will be as per requirement and/or as directed by the Owner. 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 performance requirements shall generally be as follows.

- Sp. Gr. : 1.3 to 1.4
- Shore hardness : 60A to 80A
- Tensile Strength : 116kgf/cm<sup>2</sup>  
min.
- Maximum safe continuous temperature : 70°C
- Ultimate Elongation : Not less than  
300%
- Tear resistance : 45kgf/cm<sup>2</sup> min.
- Stiffness in flexure : 25kgf/cm<sup>2</sup> min.

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- Accelerated extraction
  - i) Tensile strength : 110kgf/cm<sup>2</sup>
  - ii) Ultimate elongation : 250%
  - iii) Water absorption in 7 days : 5% (max.)
- Effect of Alkali : 7 days
  - i) Weight increase : 0.25% max.
  - ii) Weight decrease : 0.10% max.
  - iii) Hardness change : ±5
- Effect of Alkali : 28 days
  - i) Weight increase : 0.40% max.
  - ii) Weight decrease : 0.30% max.
  - iii) Hardness change : ±1%

**C) Sealing Compound**

i) Hot applied Bitumen Sealing Compound

The bitumen sealing compound shall be from approved manufacturer and shall conform to the requirements of IS: 1834. For joints in concrete lining on canals/reservoirs, sealing compound conforming to IS:5256 shall be used.

ii) Polysulphide Sealing Compound:

This shall be two-part polysulphide sealant and shall be from approved manufacturer, conforming to IS:12118. Materials shall consist of polysulphide polymer and a curing agent. Gun grade material shall be used unless otherwise specified. The application of the sealant shall be strictly followed as per manufacturer's guidelines.

**D) Joint Sealing Strips**

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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 G.I. Aluminum, or Copper, or non-metallic like rubber or P.V.C.

Sealing strips will not have any longitudinal joint and will be procured and installed in largest practicable lengths having a minimum number of transverse joints. The material is to be procured from reputed manufacturers having proven records of satisfactory supply of joint strips of similar make and shape for other jobs. The jointing procedure shall be as per the manufacturer's recommendations, revised if necessary, by the Engineer. The Contractor is to supply all labour and material for installation including the material and tools required for jointing, testing, protection, etc. If desired by the Engineer, joints in rubber seals may have to be vulcanized.

**1) Metal Sealing Strips**

Metal sealing strips shall be either G.I., Aluminium or Copper and formed straight, U shaped, Z shaped or any other shape and of thickness as indicated in the drawing. 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. If required, the Contractor will adopt longer lap lengths and different method of brazing which will render it leak proof. The edges shall be neatly crimped and bent to ensure proper bond with the concrete.

**i) G.I. Strips**

G.I. strips shall be minimum 1.5 mm thick and 150 mm in width unless specified otherwise. The standard of Galvanizing shall be as per relevant Indian Standards for heavy-duty work. At the joints, the overlapping should be for a minimum length of 50 mm.

**ii) Aluminium Strips**

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Aluminium strips shall be minimum 18 SWG thick and 300 mm wide unless specified otherwise and shall conform to IS: 737 of 19000 grades or 3J000 grade (Designation as per IS: 6051). A minimum lap of 50 mm length is required at the joints.

**iii) Copper Strips**

The Copper strips shall be minimum 18 SWC in thickness and 300 mm width unless specified otherwise and shall conform to the relevant Indian Standards. It should be cleaned thoroughly before use to expose fresh surface, without any reduction in gauge. A minimum lap of 50 mm in length is required at the joints.

**2) Non-metallic Sealing Strips**

These will be normally in Rubber or P.V.C. Rubber or P.V.C. joint seals can be of shape having any combination of the following features:

- i) Plain
- ii) Central bulb
- iii) Dumb-bell or flattened ends
- iv) Ribbed and Corrugated Wings
- v) V shaped

As these types of seals can be easily handled in very large lengths unlike metal strips, transverse joints will be allowed only under unavoidable circumstances and with the specific approval of the Engineer. The method of forming these joints, laps etc. shall be as specified by the Manufacturer and/or as approved by the Engineer taking particular care to match the central bulbs & the edges accurately.

**3) Rubber Sealing Strips**

The minimum thickness of Rubber sealing strips shall be 3 mm and the minimum width 100 mm. The actual size and shape will be as shown in drawings or as

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directed by the Engineer. The material will be natural rubber and be resistant to corrosion, abrasion, and tear and also to attacks from the acids, alkalis and chemicals normally encountered in service. The physical properties will be generally as follows. The actual requirements may be slightly different as decided by the Engineer:

Specific Gravity	1.1 to 1.15
Shore Hardness	65A to 75A
Tensile Strength	25 - 30 N/Sq.mm
Maximum Safe Continuous Temperature	75 C
Ultimate Elongation	Not less than 350%

**4) P.V.C. Sealing Strips**

The minimum thickness of P.V.C. sealing strips will be 3 mm and the minimum width 100 mm. The actual size and shape will be as shown in drawings or as directed by the Engineer. 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 Engineer, may vary slightly.

Specific Gravity	1.3 to 1.35
Shore Hardness	60A to SOA
Tensile Strength	10 - 15 N/Sq.mm
Maximum Safe Continuous Temperature	70 Deg.C
Ultimate Elongation	Not less than 275%

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**E) Polymer Modified Cement Slurry**

Acrylic polymer to be used with cement slurry shall be as approved by the Owner. The Polymer modified cement slurry may be used either in joints in concrete for sealing or as water proofing membrane over concrete surface mentioned elsewhere in this specification.

**F) Vibration Damping Pad**

The vibration damping pad material shall be resilient rubber pads made up of natural or synthetic rubber and shall have the following physical properties:

- |  |              |
|--|--------------|
| i) Shore 'A' durometer hardness  | 50 + 5       |
| ii) Minimum elongation   | 450%         |
| iii) Ultimate minimum tensile strength   | 145 kg/sq.cm |
| iv) Rubber pads shall not absorb more than 10% of weight of water in a 7 day test. |              |

The minimum thickness of the resilient pads shall be 12 mm.

**1.9.3 CODES AND STANDARDS**

For applicable codes and standards, refer relevant clause covered under specifications for cast-in-situ concrete and allied works, in addition to the codes and standard mentioned at various places under this division.

**1.9.4 TECHNICAL REQUIREMENTS - INSTALLATION**

**1.9.4.1 INSTALLATION**

**A) Bitumen Impregnated Fibre Board**

The bitumen impregnated fibre board may be secured to vertical concrete by nails in the first placed concrete. The joint filler shall be coated on both faces with coal

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tar pitch conforming to IS: 216 or bitumen of suitable grade conforming to IS: 73 or IS: 702.

**B) Expanded Polystyrene Board**

The expanded polystyrene board non-self extinguishing type (Type-1) shall be provided to create the gap between the building foundations and the machine foundations and held in position by suitable independent support and or nailed to adjoining shuttering. This shall be left in position as it is after completion of the concreting work. Shuttering shall not be put on the face of the concrete foundations separated by expanded polystyrene.

**C) Water Stops**

- i) Water stops shall not have any longitudinal joints 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 and shall be reviewed and approved by the Owner. Suitable field splicing kit including heater shall be used for this purpose. The edges shall be neatly crimped and bent to ensure proper bond with the concrete.
- ii) As Non-metallic Water Stops can be easily handled in very large lengths unlike metal strips, transverse joints will be allowed only under unavoidable circumstances and with the specific approval of the Owner. The method of forming these joints, laps, etc. shall be as specified by the Manufacturer and/or approved by the Owner, taking particular care to match the centre and the edges accurately.
- iii) Particular care shall be taken for the correct positioning of the water stops to prevent any faulty installation, which may result in joint leakage.
- iv) Adequate provisions shall be made to support the water stops during progress of work and to ensure their proper embedment in the concrete. The symmetrical halves of the water stops shall be equally divided between the concrete pours adjacent to the joints.

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- v) Maximum density and imperviousness of the concrete shall be ensured by thoroughly working in the vicinity of joints. However, particular care should be exercised in use of vibrators in the proximity of joints to avoid dislodging of the water stops.
- vi) Splices in the continuity of intersections of runs of water stops shall be jointed as per manufacturer's stipulations depending on the types of water stops used. In case of a cross section, overlapping must not be done but instead factory made cross joint should be used. It is essential that the material is not damaged during the splicing operation and that the continuity of the entire water stops across the section be maintained.

**D) Sealing Compound**

The application of the sealant shall be strictly followed as per manufacturer's guidelines.

**E) Joint Sealing Strip**

The metal sealing strips shall be pinned (using stainless steel) at one end and slotted at the other end. Exposed surface of mild steel shall be painted with two coats of approved anti-corrosive paint (as per- IS:2074) and/or bituminous paint. Welding of Aluminium shall be in accordance with IS: 2812.

**F) Vibration Damping Pad**

The resilient pads shall be installed around the foundations or at other locations as per requirement. The pads shall be installed in position by sticking the same to the foundations by using approved glue.

**G) Polymer Modified Cement Slurry Between Hardened Concrete And Fresh Concrete**

For application of polymer modified cement slurry for providing bond between hardened concrete and fresh concrete, acrylic polymer shall be mixed with neat cement normally 1 litre (1 Kg) of polymer compound shall be mixed with 3 Kg of cement and 1 litre of water. Minimum 2 Kg of this mix shall be provided per

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sq.m area of the concrete surface. This dose shall be based on nominal solid polymer content of 43% in the polymeric compound. In case, actual polymer content is less, the dose of polymeric compound shall be proportionally increased.

**1.9.4.2 INSPECTION**

**A) Water Stops**

All water stops installations shall be subject to inspection and approval by the Owner, before concreting operations, encasing water stops, are performed.

**B) Sealing compound**

When directed, the gap in joints shall be thoroughly cleaned and sealing compound laid as per manufacturer's specification and approved drawings. Primer shall be applied wherever required. For reservoir/canal lining, procedure as stipulated under Clause 9.0 of IS:5256-1969 shall be followed.

**C) Joint Sealing Strip**

Prior to the installation of the sealing strip, the surface of the joint shall be completely dry, whenever necessary a hot air blower shall be used. After cleaning dry surface, flue shall be applied both on the concrete and the sealing strip. Strip shall be applied with the even side towards the existing concrete surface and then pressed into the tacky glue. Additionally, it shall be nailed to prevent slip during concreting. It shall be placed in the middle of the joint, between the inner and outer reinforcement bars. Nominal length of the sealing strip shall be 15 m and the ends of the two continuous strips shall be butted together.

**D) Vibration Damping Pad**

The resilient pads shall be installed around the foundations or at other locations as per requirement. The pads shall be installed in position by sticking the same to the foundations by using approved glue.

**1.9.5 SAMPLING, TESTING AND QUALITY ASSURANCE**

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The sampling, testing and acceptance criteria of joint materials shall be as per the relevant clauses mentioned elsewhere in this specification / subsection.

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**DIVISION - X**

**WATER PROOFING / DAMP PROOFING OF CONCRETE STRUCTURES**

**1.10.1 INTENT**

This Division of specification deals with the requirements of all works for completing water proofing/damp proofing of concrete structure. This shall include water retaining and basement type structures.

**1.10.2 GENERAL REQUIREMENTS**

- i) As a general guidance, the provisions of IS: 6494 shall be followed unless otherwise mentioned.
- ii) The Contractor shall do the proper concreting with required workmanship so that concrete is water tight in itself without any water proofing treatment. The water proofing treatment shall be provided in exceptional cases, as additional precaution, as per requirement or directed by the Owner.
- iii) The work of water proofing/damp proofing of concrete structures by course of bitumen felt, blown bitumen or any other operations shall be entrusted by the Contractor to one of the well known expert agencies approved by the Owner. The Contractor shall furnish a guarantee about the satisfactory performance of the water proofing system for 10 years.
- iv) Actual type of water proofing treatment to be provided for a particular structure, shall be as per requirement or directed by the Owner.
- v) The construction joint shall also be treated by either chemical injection or by surface retarder by thixotropic gel method.
- vi) Protective Coating on inside surface: Two coats of cement based two components polymer modified flexible protective and waterproofing slurry having 1 mm thick for each coat shall be applied on the walls/floor after proper surface preparation as mentioned above. The slurry shall be applied by brush.

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- vii) Protective Coating on external surface: Two layers of (1 : 4) plaster of 12 mm thick each with waterproofing compound as per manufacturer's specification shall be provided on outer surface of concrete underground structures.
- viii) The exposed concrete surface of foundation will be protected by applying black bituminous paint as per IS: 702. However, in case ground water / soil corrosiveness is of higher order, suitable protective coating of approved manufacturer shall be applied as directed by Owner.

### **1.10.2.1 MATERIALS**

The materials shall be in accordance with the relevant clauses of Technical Specification for Properties, Storage and Handling of Common Building Materials.

#### **A) Bitumen Felt Treatment**

The bitumen felt shall conform to IS:1322 and the workmanship to IS:1609 and IS:3067. The bitumen felt shall be Hessian based. Bitumen primer shall conform to IS:3384. The bonding materials shall consist of blown type bitumen conforming to IS:702 or residual bitumen conforming to IS:73 or a mixture of the two, to withstand local conditions of prevailing temperature gradient of surface. The Contractor shall satisfy the Owner that the bonding materials proposed to be used are suitable for the particular job.

#### **B) Plastering Treatment**

Water proof cement plaster shall be prepared with cement and sand in 1:3 with suitable proportion of integral water proofing compound

Cement shall conform to IS:8112 and Sand shall be of grading zone III as per IS:383

Hexagonal galvanised netting of 0.90mm diameter and 19mm aperture size shall conform to IS:3150.

#### **C) Hot applied Bitumen treatment**

Hot Bitumen shall be of industrial grade 85/25 conforming to IS:702.

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**D) Polymer Modified Cementitious Coating Treatment**

Modified liquid polymer blend shall be a dispersion containing 100% acrylic based polymer solids.

Portland Cement based dry powder.

Clean, fine specially prepared quartz sand approximately 0.6 mm size.

**E) Chemical Injection Treatment**

The injection / grouting material shall be neat cement slurry admixed with water soluble non shrink polymer/monomer based chemical Water-cement ratio of the slurry shall not be more than 1:2. The resultant solution shall not have viscosity greater than 1.2 centipoises. Plasticizing agent shall be added wherever required.

12 mm dia (N.B) threaded nozzle of suitable length shall be used for the grouting conduit purpose, embedded in concrete.

**1.10.3 CODES AND STANDARDS**

For applicable codes and standards, refer relevant clause covered under specifications for cast-in-situ concrete and allied works, in addition to the codes and standard mentioned at various places under this division.

**1.10.4 TECHNICAL REQUIREMENTS – INSTALLATIONS**

**1.10.4.1 INSTALLATION**

**A) Bitumen Felt Treatment**

- i) Water proofing/Damp proofing for horizontal surfaces, unless specified otherwise, with two layers of felt on which subsequently concrete shall be placed, shall be provided with the following treatments:
  - A minimum of 12 mm thick plaster 1:4 (1 cement: 4 sand) with water proofing admixture/additives over PCC.

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- One coat of bitumen primer @ 0.4 kg/Sq.m minimum.
- One layer of hot applied bitumen @ 1.5 kg/Sq.m minimum.
- One layer of self finished felt (type -3, grade II as per IS: 1322).
- One layer of hot applied bitumen @ 1.5 kg/Sq.m minimum.
- One layer of self finished felt (type-3, grade - II as per IS: 1322).
- One layer of hot applied bitumen @ 1.5 kg/Sq.m minimum.
- A minimum of 12 mm thick plaster 1:4 (1 cement: 4 Sand)

**B) Water proofing/Damp proofing for other surfaces (including vertical), unless specified otherwise, with two layers of felt shall be provided with following treatments:**

- One coat of bitumen primer @ 0.4 kg/Sq.m minimum.
- One layer of hot applied bitumen @ 1.5 kg/Sq.m. minimum.
- One layer of self finished felt (type-3, grade-II as per IS:1322).
- One layer of hot applied bitumen @ 1.5 kg/Sq.m. minimum.
- One layer of self finished felt (type-3, grade-II as per IS:1322).
- One layer of hot applied bitumen @1.5 kg/Sq.m minimum.
- A minimum 25 mm thick plaster 1:4 (1 cement: 4 sand).
- Half brick masonry work in cement mortar 1:4 (1 cement: 4 sand) using bricks of class designation 75, unless otherwise specified.

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In addition to the normal treatment described above, heavy/extra heavy treatment shall be provided, wherever required as per IS:1609.

**C) Plastering Treatment**

After the side walls are constructed and allowed to undergo the specified curing, the surface of the walls and the flooring should be made rough with a hacking tool, washed clean with water and wire brushed so as to remove all the loose material, and a waterproof cement plaster 1:3 mix, with suitable proportion of an integral water proofing compound shall be applied in two coats, the first coat being 12 mm thick and the next 10 mm thick. The second coat shall be applied after allowing a time interval of at least 24 hrs. for the first coat to harden. Hexagonal galvanised netting of 0.90 mm dia, 19 mm aperture size shall be used in the plastering. The netting shall be fixed with the help of MS screws, fixed with the help of fibrous plugs provided in the holes drilled in the concrete surface. Netting shall be provided before application of first layer of plaster.

**D) Hot Applied Bitumen Treatment**

The external concrete surface / plastered concrete surface shall be carefully cleaned, cured and allowed to dry for some time before the application of a coat of hot bitumen of the industrial grade 85/25 conforming to IS:702 against ground water seepage. Rate of application of bitumen shall not be less than 1.7 kg/m<sup>2</sup> and it should be heated to about 120°C before application. Anti- stripping compound shall be added. Anti-stripping and adhesion improving agent shall be 100% mixable in bitumen. The stripping value tested as per IS:6241 should be nil when recommended quantity of anti-stripping compound is mixed. Nominal- mix proportion of the compound shall be 1 percent by weight of bitumen. However, actual mix proportion shall be as per manufacturer's recommendation.

**E) Polymer Modified Cementitious Coating Treatment**

i) Mixing

The liquid polymer shall be stirred well and cement based powder shall then be added slowly to make a Slurry Mix. For preparation of Brush Topping

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Mix, quartz sand shall be added slowly and mixed well with mechanical stirrer till a homogeneous mixture is obtained. The mix shall be used within half an hour of the preparation. Addition of quartz sand may not be necessary, in case dry power contains the same.

ii) Properties of the Coating

- It must adhere to the wet surface.
- It should develop adequate bond strength, with the concrete surface, not less than 2 N/Sq.m
- Co-efficient of permeability shall be about 5 x 10<sup>-10</sup> cm/s.
- Water absorption after continuous soaking shall not be more than 1%.
- The materials shall be permeable under water vapour.
- The material shall be resistant to acids and alkalies present in the soil and underground water with normal pH value between 4 and 14.
- The coefficient of thermal expansion of the material shall be close to that of concrete.

iii) Application

The concrete surface shall be cleaned and made free from grease, oils or loosely adhered particles. The surface shall be damp without any free water.

- For Slurry Mix : A minimum of 2 coats shall be applied on the surface. The first coat being applied, when the surface is still damp and left to harden for 4 to 6 hours. After 4 to 6 hours of the application of second coat, it shall be finished by rubbing down with a soft dry sponge. The coverage shall not be less than 1.1 kg/ m<sup>2</sup> in the 2 coats. A lap of 75 mm shall be provided at the joints.
- The coating shall be air dried for 4 to 6 hours and, thereafter, cured for 7 days after the application of last coat.

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- For Brush Topping Mix : This shall be applied in two coats. A primary coat of slurry mix can also be first applied on the surface as first coat. After the coating has dried up, a coat of Brush Topping Mix shall be applied over its with a push broom or any other similar brush. It shall be left in broom finished condition. The nominal thickness shall be 1.5 mm and minimum thickness shall be 1.0 mm. A lap of 75 mm shall be provided at the joints. It shall be ensured that no pinhole exists and rebrushing shall be done to cover the pinholes, if any.
- The Coating shall be air dried for 4 to 6 hours and thereafter cured for 7 days after the application of last coat.

**F) Chemical injection Treatment**

Wherever shown on the drawing or directed by the Owner, minimum, 12 mm dia (N.B) threaded nozzle of suitable length, shall be provided over the surface and along the construction joint line in a grid pattern at a spacing not exceeding 1.5 m c/c before concreting operation. Adequate precaution shall be taken to keep the nozzles plugged at both ends to prevent them from getting closed by concrete.

For fixing of any nozzle in set concrete suitable size hole shall be drilled, preferably by using drill, electrically operated, in grid pattern and grouting nozzle shall be fixed in these holes. After the nozzles are fully set, neat cement slurry admixed with water soluble non shrink polymer/monomer based chemical shall be injected through the net-work of nozzles with low pressure grout pumps at a pressure of about 2.0 kg/sq. cm. Water-cement ratio of the slurry shall not be more than 1:2. The resultant solution shall not have viscosity greater than 1.2 centipoises. Plasticizing agent shall be added wherever required. The grouting shall be started at very low pressure and increased gradually to a required pressure. The grouting shall continue, till the hole refuses to take any further grout, even at an increased pressure. Applied pressure shall not be more than the designed strength of the concrete. After completion of grouting operation, the nozzles shall be sealed properly to the satisfaction of the Owner.

**G) Surface retarder by thixotropic gel method**

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A surface retarder in the form of a thixotropic gel shall be applied on the joint surface of the previous pour in case of joint on the wall and in case of floor the same shall be applied on the formwork against which previous pour of concreting shall be done. The retarder may be liquid or paste form depending on the type of formwork. The formwork shall be removed within 24 hours after concreting. Within 2 hours of striking of the formwork the retarder shall be washed off with strong water jet to make surface rough and clean. Then a rich cement mortar using cement, sand and aggregates (maximum size 8 mm) along with synthetic rubber emulsion type water resistant bonding agent shall be applied for a depth of 50 mm just before pouring the next stage of concreting. In case of walls, the above bonding agent will be mixed with water, which will be used for making the cement mortar. The proportion of mixing of this bonding agent with water shall be as per manufacturer's specification. In case of floor joint, however, after washing of retarder a solvent free two-component epoxy resin-bonding agent will be used at the joint before the next pour of concrete. The above bonding agent shall have the following properties after 28 days

Compressive strength	55 to 60 N/Sq.mm
Flexural strength	5 to 30 N/Sq.mm
Tensile strength	15 N/Sq .mm (approx.)
Bonding strength to concrete	3 N/Sq.mm (approx.)
Bonding strength to steel	20 N/Sq.m (approx.)

The whole operation shall be done as per manufacturer's specification. The contractor shall provide manufacturer's supervision at no extra cost to the owner.

#### **H) Polyethylene Films**

Waterproof treatment using polyethylene shall be applied as outlined and as per sequence given hereunder

- 1) The concrete surface shall be made smooth with 12 mm cement plaster 1:6.
- 2) Apply hot bitumen 80/100 grade (IS: 73-1961) at the rate of 1.0 Kg/Sq.m minimum

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- 3) Lay black polyethylene film 250-micron (IS: 2508-1977) with cut back bitumen adhesive in overlaps over hot bitumen surface, gently pressed, taking care not to puncture the film.

Alternatively, the overlaps shall be heat sealed by an electric iron having three parallel sealing bars. A long piece of plywood is to be placed below the polyethylene film to be heat-sealed. On the plywood a rubber gasket is to be laid to provide a cushion for better welding of the film. On the rubber padding, a cellophane tape is to be spread and on this the LDPE film, with 100 mm overlap, is to be stretched. On the overlapped film another cellophane tape is to be placed to prevent the heat sealer from sticking to the LDPE film. After this, the electric iron is to be pressed on the overlap joint for sufficient time so as to allow perfect welding. The operation is to be repeated for subsequent lengths of joints. After heat-sealing, the cellophane tape is to be removed and the joints are to be tested for leaks.

- 4) Lay 100 gm brown craft paper laminated with a layer of straight run bitumen,  
5) Lay hot bitumen 80/100 grade (IS: 73-1961) at 1.0 Kg/Sq.m minimum.  
6) Lay 250-micron polyethylene film as second layer similar to above.  
7) Lay second layer of 100 gm. brown craft paper laminated similar to (4) above.  
8) Apply hot bitumen (straight run grade) to IS: 73 -1961 at 1.0 Kg/Sq.m dusted with fine sand.  
9) Protecting with a layer of 75 mm plain cement concrete M-10, or a layer of brick laid in cement mortar 1:6 in case of wall apply a 12 mm thick plaster as shown on the drawing or a protective brick wall in 1:6 cement mortar as shown on the drawing.

**J) Bitumen Felt for Tanking**

This specification shall cover laying the waterproof course on the outside and - inside of the walls and bases of structures.

The materials shall conform to IS: 1322, and the workmanship to IS: 1609. The bitumen felt should be Hessian base and/or fiber base as specified in Drawing. If required by the Engineer, tests as specified in relevant IS Codes shall be arranged by the Contractor without charging any extra to the Owner.

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The Contractor shall execute this work in direct collaboration with one of the well known specialized firm approved by the Engineer.

Cleaning the surface, keeping it dry, providing, necessary corner fillets and cement rendering and cutting chases, etc. shall be done as per drawings and/or instructions. If any protective brickwork on/against concrete sub-bases or walls are required, the same shall be provided. A twenty (20) years guarantee for satisfactory performances shall be given by the Contractor as well as by his specialist sub-contractor jointly and severally, for this work. Free rectification of any defects noted in the work within this guarantee period will be carried out by the Contractor even if it is beyond the specified maintenance period of the contract as a whole.

**1.10.5 SAMPLING, TESTING AND QUALITY ASSURANCE**

The sampling, testing and acceptance criteria of material and work shall be as per the relevant clauses mentioned elsewhere in the specification, approved field quality plan (FQP), manufacturer's recommendation and relevant IS Codes / Standards.

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**DIVISION - XI**

**DISMANTLING/DEMOLISHING WORK - RCC AND PCC**

**1.11.1 INTENT**

This Division of specification deals with the requirements of dismantling / demolishing RCC and/or PCC work.

**1.11.2 GENERAL REQUIREMENTS**

- i) The dismantling implies carefully breaking up a structure / member in part or full and removing without damage to balance or adjoining structure as specified or per requirement or as directed by the Owner. This shall consist of dismantling one or more parts of a structure. This includes chipping work, making holes/opening etc. in concrete member, according to the required shape, size, and profile at all elevations,
- ii) The term demolition implies, taking up or down or breaking up of a structure/member, in part or full, as specified or per requirement or as directed by the Owner.
- iii) In a structure/member, both dismantling and demolishing work may be involved. In such case, the portion of work treated as demolishing shall be as shown on the drawing or as decided by the Owner.
- iv) All materials obtained from the demolition/dismantling work, shall be property of the Owner, unless otherwise specified.
- v) All serviceable materials obtained shall be separated out and stacked properly upto a lead of 500 metres or shall be returned to Owner's stores and all unserviceable materials, rubbish etc., shall be disposed off as directed by the Owner upto a lead of 2 kms.

**1.11.3 CODES AND STANDARDS**

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For applicable codes and standards, refer relevant clause covered under specifications for cast-in-situ concrete and allied works, in addition to the codes and standard mentioned at various places under this division.

**1.11.4 TECHNICAL REQUIREMENTS - EXECUTION**

- i) The dismantling/demolishing operations shall be carried out in proper sequence so that the serviceable material can be salvaged, without being damaged during the process of work.
- ii) Necessary propping, shoring and under pinning shall be provided for the safety of the adjoining work or property which is to be left intact before dismantling / demolishing work.
- iii) All demolition work shall be carried out in conformity with the local safety regulations, extreme caution being exercised to avoid damage to the work and the equipment, which are to be left intact. Necessary precautions shall be taken to keep the dust nuisance down. Safety requirements stipulated in IS: 4130 shall also be followed.
- iv) As and where necessary, the dismantled/demolished materials shall be lowered to the ground and not thrown and then properly stacked as directed by the Owner. Wherever required, temporary enclosures shall be erected to minimise the dust or moisture infiltration.

**1.11.5 SAMPLING, TESTING AND QUALITY ASSURANCE**

Not applicable

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**DIVISION - XII**

**ADDITIVES/ADMIXTURES IN CONCRETE**

**1.12.1 INTENT**

This Division of specification deals with the requirements of furnishing, placing and mixing cement additives / admixtures in all kinds of cement concrete, (plain or reinforced) for all kinds of structures at all levels.

**1.12.2 GENERAL REQUIREMENTS**

- i) The Contractor shall furnish all labour and equipment to place and mix water proofing cement additive and cement plasticizer in concrete of any grade and cement mortar. Thereafter, he shall carry out the work as specified earlier in relevant clauses of this specification for concrete and hence complete the work as indicated on the drawing and as per the specification listed hereunder.
- ii) The waterproofing admixture for concrete and cement mortar/plaster shall conform to IS: 2645. The admixture shall not cause decrease of strength of concrete/plaster at any stage and it shall be free from chlorides and sulphates. The admixture shall not affect the setting time by more than 5%. The maximum permissible dosage of admixture will be 3% (three percent) by weight of cement, but a lower dosage will always be preferred. The product shall be stored in strong moisture proof packings. However, in case of important structures where M25 or higher grade concrete is specified, the use of melamine based, high range water reducing concrete admixture shall be used to provide a waterproof concrete, For achieving high strength concrete having cement content around 400 kg/cu.m. a melamine based super plasticizer will be preferable.
  - a) **In concrete:** The admixtures shall be procured from reliable and reputed manufacturers and approved by the Engineer. The method of application and other details shall conform to the manufacturer's specification and/or as instructed by the Engineer. The Contractor shall have the services of the manufacturer's supervisor at no extra cost to supervise the work, if desired by the Engineer.

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**b) In Plaster:** The concrete surface, to be plastered, shall be hacked to Engineer'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 layers not exceeding 15 mm/layer or as per manufacturer's specification. The additive shall be of quality and type approved by the Engineer. If desired by the Engineer, the Contractor shall have the work supervised by the manufacturer's supervisor at no extra cost. On completion, the Plastered surface shall be cured continuously for a minimum period of 14 days like concrete.

- iii) The Contractor shall have the services of the manufacturer's supervisor at no extra cost to the Owner, to supervise the work, if directed by the Owner.
- iv) Admixtures in concrete for promoting workability, improving strength, entraining air or for similar purposes may be used only after the written permission from the Owner is obtained. Addition of admixtures shall not reduce the specified strength or durability of concrete in any case. The admixtures shall conform to IS:9103 and shall be of proven make and from a reputed manufacture. Calcium chloride shall not be permitted to be used other than in mass (plain) concrete works.

#### **1.12.2.1 MATERIALS**

Water proof cement additive shall conform to IS:2645 and shall be of proven make and from a reputed manufacturer.

Admixtures in concrete shall conform to IS:9103 and shall be of proven make and from a reputed manufacturer. In addition, for Plasticizer-cum-water proofing compound, materials shall meet the permeability requirements as per IS:2645. Similarly for plasticizer-cum retardar admixture material shall satisfy the setting time requirements of retardar and other properties of plasticizer as per IS:9103.

#### **1.12.3 CODES AND STANDARDS**

For applicable codes and standards, refer relevant clause covered under specifications for cast-in-situ concrete and allied works, in addition to the codes and standard mentioned at various places under this division.

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**1.12.4 TECHNICAL REQUIREMENTS – INSTALLATION**

- i) Admixtures / water proofing additive shall be used at the rate specified by the manufacturer or as indicated on the drawings and shall be mixed with water, as required by the Owner.
- ii) Samples of concrete in which admixture and/or water proofing cement additive is added shall be tested for water proofness, workability, compressive strength, water absorption, density, setting time, etc., The results shall conform to relevant IS specifications.

**1.12.5 SAMPLING, TESTING AND QUALITY ASSURANCE**

As per manufacturer's recommendation

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**DIVISION - XIII**

**CONCRETING OF MAJOR EQUIPMENT FOUNDATION**

**1.13.1 INTENT**

This Division of the specification deals with the special requirements for concreting of foundations for Turbo-generator and other major equipment foundation as specified in the drawings or as directed by the Owner.

**1.13.2 GENERAL REQUIREMENTS**

- i) Unless specified otherwise in this Division of specifications, the technical specifications for cast-in-situ concrete, formwork, reinforcement etc. which are required for the construction of major equipment foundations have been covered under Technical Specifications for concrete and Allied works which shall be deemed to form a part of this specifications / subsections.
- ii) In addition to the stipulations mentioned elsewhere, special requirements mentioned under the following clauses shall be followed for concreting of major equipment foundations.

**1.13.2.1 MATERIALS**

**A) Concrete**

Grade of concrete shall be M-25 minimum or higher as specified in the drawings and schedule of items.

**B) Coarse Aggregates**

- i) Sound and durable crushed stone aggregates shall be used. All aggregates shall be tested for alkali - aggregate reaction. Materials which contain high percentage of reactive silica shall not be used. Lime stone aggregate shall not generally be used for concreting of foundation which are subjected to high temperature and repeated temperature cycles (like in the case of GT foundation).

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- ii) In case other types of suitable aggregate is not available, the Owner may allow the use of lime stone aggregate, provided the Contractor gets the sample tested from a reputed testing laboratory for satisfactory performance under high temperature and repeated temperature cycles. Unless otherwise specifically approved by the Owner, the tests shall be carried out for a temperature range from 10 °C to 65 °C and for 60 (sixty) temperature cycles.
- iii) Graded aggregate upto 40 mm (max.) size shall be used unless modified otherwise. For narrow sections and areas having congestion of reinforcement smaller size aggregates may be used.

**C) Temperature Control of Concrete**

All large-size pours, which generate high heat of hydration, require control of temperature of fresh concrete to minimise thermal cracking the development of stress due to early thermal contraction. Temperature control shall be exercised for concreting of ST top deck and GT inertia block. The temperature of fresh concrete shall not exceed 25 °C when placed. For maintaining the limiting temperature of 25 °C, crushed ice shall be used in mixing water. The Contractor shall establish by means of trial mixes the quantity of crushed ice to be mixed in order to achieve the temperature. In addition to mixing of ice, other methods for control of temperature like cooling of aggregate (including storing under shed) may also be resorted to.

**D) Admixture**

Plasticizer-cum-retarder type admixture shall generally be added to the concrete for promoting workability in addition to retarding setting time for mass concreting work. However, for small volume work, only plasticizer shall be used. Addition of admixture should not reduce the specified strength of concrete in any case. Fresh mix design shall be carried out using the admixture. Performance of the admixture with respect to workability and setting time shall be verified by testing the same batch of material to be actually used for concreting.

**1.13.3 CODES AND STANDARDS**

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For applicable codes and standards, refer relevant clause covered under specifications for cast-in-situ concrete and allied works, in addition to the codes and standard mentioned at various places under this division.

**1.13.4 TECHNICAL REQUIREMENTS - INSTALLATION**

**1.13.4.1 FORM WORK**

- i) The Contractor shall prepare design and drawings for the formwork (including staging) and get the same approved by the Owner prior to taking up the work. The shuttering system shall be so designed that it does not undergo excessive settlement and the maximum settlement shall be restricted to 5mm. In case, the formwork gets disturbed or damaged during construction, the same shall be suitably rectified and strengthened, if necessary. The approval of the formwork arrangement by the Owner will not relieve the Contractor of the responsibility for adequacy of the design and correctness as per the drawing.
- ii) The materials to be used in the formwork and its method of construction shall be subject to the approval of the Owner. The formwork shall be of rigid construction. Form shall be built true to shape, lines and dimensions as indicated in the approved drawings. These shall be properly braced and strutted to maintain correct position and shape during the concreting. The side shuttering shall be properly braced / supporting in order to avoid any bulging.
- iii) In order to avoid segregation of concrete, windows shall be provided in the formwork at various levels for chute concreting.
- iv) Forms shall be left in place until removal is authorised and shall be removed carefully to avoid damage to the concrete. Form removal will be authorised and carried out as per schedule to be approved by the Owner. The forms on sides shall be removed as soon as practicable to permit start of curing.

**1.13.4.2 REINFORCEMENT**

- i) Lapping / splicing of reinforcements shall be staggered and under no circumstances it shall exceed 50 percent of the total no. of bars at any given location. Splicing shall generally be done by lapping. However, Owner may allow splicing by welding or by mechanical anchoring.

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- ii) Mechanical jointing of bars (Bar grips) if permitted by the Owner shall be so designed as to develop the full strength of the bars being spliced. There shall be no slip in the joints. Mechanical anchoring of bars shall be done by a specialist agency having the required expertise and experience in doing such jobs.
- iii) Sample tests of the mechanical bar grips shall be carried out upto the yield strength of reinforcement bars. The number of tests to be carried out shall be 3 (three) percent of the no. of bar grips used subject to a minimum of three. The results of such tests shall be furnished. The minimum length for splicing should be as mentioned in drawings.

#### **1.13.4.3 CONCRETING**

##### **A) Scheme for Concreting**

The Contractor shall prepare a comprehensive scheme for mass concreting depending upon the type of foundation, nature of work and quantity of concrete for carrying out uninterrupted concreting. This shall include arrangement for stacking and handling of ingredients, number and capacity of plants and equipment, manpower requirement for each shift of work, arrangement of handling and placement of concrete, temperature control scheme, time required for completion, contingency arrangement for any eventuality etc. Weigh Batching Plants shall be used for all machine foundations. Concrete pump shall be mobilised for ST basement, ST Top Deck and GT foundation. Arrangements for stand-by Plant and Equipment shall also be made.

##### **B) Placing of Concrete**

- i) Base mat/raft and top deck of Steam Turbine Foundation and entire Gas Turbine Foundation shall be cast- in a single pour. In other cases, such as columns of Steam Turbine Foundation. Construction joints may be allowed in case the same is shown in the construction drawings.
- ii) Concrete shall not be placed until final check of the forms is completed. The forms shall be properly oiled and all debris removed from within the formwork.

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- iii) Forms shall be thoroughly wetted and the free moisture removed. No concrete shall be placed directly against the soil except against the lean concrete at the base. Construction joints shall be provided only at the places indicated in the drawings. The concrete shall be deposited in such a manner so as to prevent segregation. Concreting at spaces not easily approachable shall be carried out by chutes with a properly designed mix and through special windows in the formwork so as to minimise segregation. In case, it becomes unavoidable to place the concrete from greater height than permissible (1.8m), suitable arrangements like elephant tusk etc. shall be used for placing the concrete in position. Each layer shall be plastic when the new layer is placed upon it.
- iv) Concrete shall not be placed under water. To secure maximum density and to eliminate formation of entrained air pockets, concrete shall be thoroughly vibrated and worked by internal or immersion vibrators of high speed around the reinforcement, during and immediately after placing ensuring that segregation in concrete does not take place. The vibrators shall penetrate the layer being placed and ensure thorough vibration, good bond and homogeneity between two layers and prevent the formation of cold joints. Care shall be taken to prevent contact of vibrators against reinforcement steel. Vibrators shall also not be allowed to come in contact with forms and finished surfaces.
- v) The use of form attached vibrators shall not be permitted without specified authorisation of the Owner.

**C) Slump**

- i) Large slumps for better workability shall be required due to presence of heavy reinforcement, large pour height and for achieving honeycomb-free concrete.
- ii) The mix design of the concrete should take care of such higher slump. Values of the slump to be adopted for various areas / type of foundations are given below as a guidance only. However, actual slump shall be decided by the Owner on a case to case basis.

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- STG / GT foundation - 100 mm to 150 mm
- Other Machine foundation – 75 mm to 100 mm

#### **1.13.4.4 CURING OF CONCRETE**

All concrete placed shall be cured for a period of not less than 21 days by keeping it damp. Except when otherwise directed by the Owner, all concrete shall be cured by use of water, which shall be continuously sprayed or ponded on all exposed surfaces. Curing shall be carried out by ample water supply under pressure in pipes with all necessary appliances, such as hose, sprinklers and spraying. Sprinklers shall be used unless otherwise specified or approved by the Owner. Whenever it may be necessary in the judgement of the Owner, ponding method of curing shall be used.

#### **1.13.4.5 RECORDS OF CONSTRUCTION**

All records of concreting, testing of materials of concrete, as built dimension, insert details, and the details of the rectification shall be maintained.

- i) Testing Data of aggregates including test records of aggregates subjected to repeated temperature cycles.
- ii) Mix Design Details.
- iii) Testing records of Admixture including dosage, workability and setting time.
- iv) Quantity of ice used and temperature of concrete.
- v) Hourly records of concreting including pour card.
- vi) Protocol indicating the dimensional tolerance and details of inserts.
- vii) Records giving the details of rectification giving the location of grouting, the quantity of grout used at each location, type of grout used.
- viii) Bar Bending Schedule.
- ix) Location and Details of mechanical anchoring, if used.

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- x) Protocol giving the details of checking of reinforcements before concreting and conformance to the reinforcement details as shown in the construction drawings.
- xi) Photographs showing the areas where rectification works have been carried out. Photographs should be taken before and after rectification.
- xii) Report on petrographic examination and potential reactivity of aggregated and the repeated temperature cycle tests.

**1.13.5 SAMPLING, TESTING AND QUALITY ASSURANCE**

For sampling, testing and quality assurance, refer stipulations of relevant clause for cast-in-situ concrete work of this specification.

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**TECHNICAL SPECIFICATION FOR PRECAST CONCRETE WORKS**

**END USER** **MADHYA PRADESH POWER GENERATING  
COMPANY LIMITED**

**LTSL PROJECT No.** **T 408000**

**LTSL DOC. No** **MALWA-SP-C-004**

**REVISION CERTIFICATION**

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**TECHNICAL SPECIFICATION FOR  
PRECAST CONCRETE WORKS**

**1.1.0 INTENT**

This specification deals with the manufacturing and erection of plain or reinforced precast concrete members including materials, labour, handling, supervision all complete as per drawing, specification, schedule of item complete and as per the direction of the Owner.

Type of precast members shall be in the form of trench/floor opening cover, fin, fascia, coping, lintel, chajja, wall panel, beam, column, blocks for road edging and roof unit.

**1.2.0 GENERAL REQUIREMENTS**

The technical specification for cement concrete, formwork and reinforcement, covered under Technical Specification for Cast-in-situ Concrete and Allied Work shall be deemed to form a part of these specifications. Wherever the stipulations of this specification conflict with the specifications of Cast-in-situ Concrete and Allied Work, this specification shall govern.

This specification covers furnishing of all labour, materials and equipment, and performing all operations required for the manufacture and transportation of precast concrete items, hoisting and fixing them in position to correct lines and levels, filling in joints and otherwise finishing, cutting of the lifting hooks etc. and testing of pre-cast members. Structural steel or other embedment, if any, shall also be embedded in precast members.

The precast member shall be manufactured in a yard at the project site. This yard shall have hard and leveled platform, and shall preferably be fenced. The Contractor shall arrange for all the necessary facilities like shed, casting bed, curing tank, handling equipment and transportation etc. complete.

The grade of the concrete and the type of precast element to be used shall be as called for in the schedule of items or as per requirement. Unless otherwise specified, minimum M20 grade of concrete shall be used.

The Contractor shall provide a complete scheme of drawing showing arrangement of casting of pre-cast concrete units including handling, curing etc. with erection program

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for the approval of the Owner. However, this approval, shall not relieve the Contractor of his responsibility for safe and sound work.

### 1.3.0 CODES AND STANDARDS

In addition to the relevant Indian Standards and codes as mentioned under Standard Technical Specification for Concrete and Allied Works, following additional applicable Indian Standards, Codes etc. are referred to here below. In case of discrepancy between this specification and those referred to herein, this specification shall govern. A copy of all these documents shall generally be available at site, with the Contractor:

SP: 7 (PART VI /Sect. 7)	National Building Code-Structural design of prefabrication and systems building.
IS :3201	Criteria for Design and construction of Pre-cast Trusses and Purlins.
IS: 10297	Code of practice for design and construction of floors and roofs using precast reinforced/ prestressed concrete ribbed or cored slab units.
IS: 10505	Code of practice for construction of floors and roofs using Precast concrete waffle units.

### 1.4.0 TECHNICAL REQUIREMENTS – LAYING AND INSTALLATION

#### 1.4.1 CONCRETE MIX

The concrete mix for various types of precast units shall conform to IS: 456. The grade of concrete for different pieces of construction shall be as specified.

Aggregates shall be mixed by weight and the water-cement ratio shall be controlled so as to obtain a dense Concrete of the required strength as per the relevant design mix consideration. The size of aggregate shall not be more than 20 mm. However for narrow and thinner sections like roof units, 12.5 mm size down graded material shall be used.

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#### **1.4.2 FORMWORK**

The form work for the precast members shall be made up of steel, plywood or wood lined with galvanised M.S. sheet so as to obtain a smooth surface after the forms are removed. The Contractor shall submit detailed drawings of formwork for approval. Vibration shall be carried out to obtain a good finish. In addition, rodding shall be done to ensure that the concrete material is evenly spread and fills all inaccessible regions. Top exposed surface shall be finished smooth with cements mortar (1:3), wherever required.

#### **1.4.3 REINFORCEMENT**

The reinforcement shall conform to IS:432 (Part-1), IS:1786 or IS:1566. Bending, binding and placement of reinforcement shall be as per IS: 2502.

#### **1.4.4 FIXING OF STRUCTURAL STEEL EMBEDMENTS**

Structural steel in the form of angles, flats, etc., which shall be either furnished by the Owner within the project area or supplied and fabricated by the Contractor, shall be transported and embedded in position in various precast members to correct lines and levels by means of welding or otherwise as indicated on the detailed working drawings.

#### **1.4.5 HANDLING**

Each precast member shall be suitably marked to indicate the top of the member and its location and orientation in the structure and date of casting in order to facilitate in distinguishing the dates of casting of various members. The Contractor shall also maintain a register indicating the date of casting of various members, curing, transportation and erection. To ensure minimum damage during handling, the Contractor shall provide suitable cranes capable of lifting the heavy pieces on to the curing tanks, stacking shed and on to the places of erection. The responsibility for any damage for whatsoever reasons it may be, shall be that of the Contractor and he shall replace the damaged pieces.

#### **1.4.6 CURING**

Either natural curing with water or an accelerated curing using steam shall be followed. Water curing shall be carried out for a period specified. This shall be done

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by providing a water tank of adequate size nearby, wherein the precast members shall be immersed.

#### **1.4.7 ERECTION**

The Erection shall be done as indicated on the working drawings. The Contractor shall provide a scheme and erection drawings for the approval of the Owner before commencement of erection.

The precast roof units/slabs shall generally rest on the steel/Concrete structure. The precast elements shall be structured in position as per requirement. Pre-cast blocks for road edging shall be laid on prepared subgrade.

The precast units shall be welded in position to the structural steel by means of matching piece already embedded in precast elements.

After the erection of the precast elements at site, the hooks provided for lifting purpose shall be cut flush to the surface of the slab as and when desired by the Owner.

While erecting, the precast elements all necessary safety precautions for the safety of equipment and structure and personnel located working in the area shall be taken. The equipment used for lifting and erecting the precast elements are lifted to position without swings or jerks. While welding the precast elements to the trusses and other steel structures, special care shall be taken to see that sparks resulting from welding shall not cause any fire hazards. Other necessary precautions shall also be taken to see that no damage is caused to equipment or personnel, located in the area.

After erection, the gaps between precast units shall be filled with cement mortar 1:3 or with concrete of mix one grade higher than that of precast unit.

#### **1.5.0 SAMPLING, TESTING AND QUALITY ASSURANCE**

All the relevant clauses pertaining to Standard technical specifications for Concrete and Allied Works shall be applicable. This shall include testing for concrete mix.

Load tests shall also be carried out for the type of members as decided by the Owner as per the provisions made under IS: 456.

Tolerance on dimensions

Tolerance on dimensions of precast units shall be as follows:

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- i) Length:  $\pm 0.1$  percent subject to minimum of  $\pm 5$  mm and maximum of  $+10$ mm.
- ii) Cross-sectional dimensions:  $\pm 3$ mm or  $\pm 0.1$  percent whichever is greater.
- iii) Straightness or Bow:  $1/750$  of the length subject to minimum of  $\pm 5$ mm and maximum of  $\pm 10$  mm.
- iv) Squareness: When considering the squareness of the corner the length of the two adjacent sides being checked shall be taken as the base line. The shorter side shall not vary in length from the perpendicular by more than 5 mm.
- v) Flatness: The maximum deviation from a 1.5m straight edge placed in any position on a nominal plane surface shall not exceed 5 mm.

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Structural Steel



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**TECHNICAL SPECIFICATION FOR FABRICATION AND ERECTION OF  
STRUCTURAL STEEL**

**END USER** **MADHYA PRADESH POWER GENERATING  
COMPANY LIMITED**

**LTSL PROJECT No.** **T 408000**

**LTSL DOC. No** **MALWA-SP-C-009**

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For Bid

L&T – Sargent & Lundy

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**TECHNICAL SPECIFICATION FOR  
FABRICATION AND ERECTION OF  
STRUCTURAL STEEL**

**1.1.0 INTENT**

**1.1.1.1** This covers fabrication, erection, alignment, welding, etc. of mild steel, medium and high strength steel at all levels, involving rolled sections (including rounds), pipes/hollow sections, built-up sections fabricated out of plates and / or rolled sections (including pipes / hollow sections), plates, chequered plates, etc., in columns, beams, gantry girders, crane girders, roof trusses, roof girders, trestles, galleries, portals, purlins, space frames, shear connectors, hangers, struts, monorail beams, stiffeners, wall beams, sheeting runners, brackets, stub columns, bracings, cleats, base plates, splice plates, chequered plate flooring, decking plates, floor plates, seal plates, diaphragms, steel frame grid over false ceiling, walkways, platforms, ladders, stairs, stringers, treads, landings, toe plates, rungs, insert plates, edge protection structures, embedments, lugs, posts, stays, gates, louvers, lacings, batten plates, stiffeners, gusset plates, washers, bunkers, silos, hoppers, all sampling and testing etc. all complete.

**1.1.1.2** The provisions of IS: 800 shall be followed as general guidance along with all other relevant Indian Standards, Codes and Acts, unless otherwise specifically mentioned.

**1.1.1.3** Work to be provided by the Contractor, unless otherwise specified elsewhere in the contract, shall include, but not limited to the following :-

- Preparation and checking of complete detailed fabrication drawings and erection markings required for all the structures covered under the scope of the contract based on design drawings to be furnished by the Owner.
- To submit revised design with calculations and detailed fabrication drawings in case any substitution of designed sections are to be made.
- To submit design calculations for joints and connections developed by the Contractor along with detailed fabrication drawings and getting the same approved.

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- Supply, Fabrication, Erection, Alignment, Bolting, Welding, Testing etc. complete including one shop coat of primer painting as specified elsewhere in the specification.
- Prepare and submit monthly material reconciliation statement showing effective utilization of raw materials as received from Owner's stores.
- Furnish quarterly and monthly requirement of matching steel sections for maintaining required progress of fabrication in accordance with the approved programme and take delivery of raw materials from Owners stores.
- Marking and packing for transport of fabricated materials.
- Prepare and furnish detailed Bill of Materials (BOM), Drawing Office Dispatch Lists, Bolt List and any other list of Bought Out Items required in connection with the fabrication and erection of structural steelworks.
- Dismantling, modification and re-erection of fabricated / erected steel members complete with touch-up work.
- Maintain a fully equipped workshop at site for fabrication, modification and repairs of steelworks at site as may be required to complete the works in accordance with the Contract.
- Establish stores for safe preservation of all consumable, inspection tools / gauges and all quality records regarding materials, equipment, fabrication and erection.
- Maintain a fully equipped field laboratory as required for quality assurance. No work under this specification shall be provided for by any agency other than the Contractor, unless specifically mentioned otherwise elsewhere in the contract.
- Furnish all materials, labour, tools and plant and all consumables required for fabrication and supply, all necessary rivets, bolts, nuts, washers, tie rods and welding electrodes for field connections.
- Suitably mark, bundle, and pack for transport all fabricated materials.
- The Contractor shall provide all construction and transport equipment, tools, tackle, consumables, materials, labour, and supervision required for erection of the structural steelwork.

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- Receiving, unloading, checking, and moving to storage yard at Site including prompt attendance to all insurance matters as necessary for all fabricated steel materials arriving at Site. The Contractor shall pay all demurrage and/or wharfage charges etc. on account of default on his part.
- Transportation of all fabricated structural steel materials from Site storage yard, handling, rigging, assembling, riveting, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and/or as directed by the Engineer. If necessary suitable temporary approach roads to be built for transportation of fabricated steel structures.
- Checking center lines, levels of "all foundation blocks including checking line, level, position and plumb of all bolts and pockets. Any defect observed in the foundation shall be rectified with Engineer's approval. The Contractor shall fully satisfy himself regarding the correctness of the foundations before installing the fabricated steel structures on the foundation blocks.
- Aligning, plumbing, leveling, riveting, bolting, welding and securely fixing the fabricated steel structures including floor gratings, chequered plates etc. in accordance with the Drawings or as directed by the Engineer.
- Painting of the erected steel structures.
- All minor modifications of the fabricated steel structures as directed by the Engineer including but not limited to the following:
  - i) Removal of bends, kinks, twists etc. for parts damaged during transport and handling.
  - ii) Cutting, chipping, filling, grinding, etc. if required for preparation and finishing of site connections.
  - iii) Reaming of holes for use of higher size rivet or bolt if required.
  - iv) Re fabrication of parts damaged beyond repair during transport and handling or re- fabrication of parts, which are incorrectly fabricated.

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- v) Fabrication of parts omitted during fabrication by error, or subsequently found necessary.
- vi) Drilling of holes that are either not drilled at all or drilled at incorrect location during fabrication.
- vii) Carry out tests in accordance with this specification.

**1.1.1.4** The above including the details shown in the Bid drawings, are for the purpose of illustration. It is possible that some items indicated above may not appear in actual work and on the other hand some other items not specifically mentioned above but similar in nature will have to be executed as per the relevant drawings and instruction of Owner.

No work under this specification will be provided for by any agency other than the contractor, unless specifically mentioned otherwise elsewhere in the contract.

**1.1.1.5 CONFIRMITY WITH DESIGNS**

The contractor shall design all connections, supply and fabricate all steelwork and furnish all connection materials in accordance with the detailed design drawings and/or as instructed by the Engineer keeping in view the maximum Utilization of the available sizes and sections of steel materials. The methods of painting, marking, packing and delivery of all fabricated materials shall be in accordance with the provisions of the contract and/or as approved by the Engineer. Provision of all relevant Indian Standard Specifications and Codes of Practice shall be followed unless otherwise specified in the contract.

The Contractor shall erect the entire fabricated steel structure, align all the members, complete all field connections and grout the foundations all as per the provisions of this specification and the sequence and the design criteria laid down by the Engineer. All work shall conform to the provisions of this specification and /or instructions of the engineer. The testing and acceptance of the erected structures shall be in accordance with the provisions of this Specification and/or the instructions of the Engineer.

**1.2.0 GENERAL REQUIREMENTS**

**1.2.1 General**

**1.2.1.1** The Contractor shall furnish all labour, plant, equipment, consumable, scaffolding, tools, tackles, materials and everything that is required for complete executions of the work on

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schedule in accordance with the drawings and as described herein and/ or as directed by the Owner.

### **1.2.2 Reference points and bench marks**

**1.2.2.1** The Contractor shall make his own arrangements for locating the coordinates and positions of all work and reduced levels (RL) at these locations based on two reference grid lines and one bench mark which shall be furnished by the Owner. The Contractor has to provide at site all the required survey instruments to the satisfaction of the Owner so that the work can be carried out accurately according to the specifications and drawings. Contractor shall be solely responsible for correctness of layout and levels.

### **1.2.3 Safe working**

**1.2.3.1** The Contractor shall strictly follow, at all stages of fabrication, transportation and erection of steel structures, the stipulations contained in IS:7205- Indian Standard Safety Code for Erection of Structural Steel work and the provisions of the safety rules as specified in the General conditions of the contract for ensuring safety of men and materials. This shall include proper approach and working platform during erection of the structures.

### **1.2.4 Issue of Materials**

Structural Steel, pipes, chequered plate in required sections and thickness, shall be made available by the Contractor in accordance with the procedure laid down in the Special Conditions of Contract.

### **1.2.5 Material**

All steel materials, required for the work shall be supplied by the Contractor, unless otherwise specified elsewhere in the contract. The materials shall be free from all imperfections, mill scales, slag intrusions, laminations, fittings, rusts etc. that may impair their strength, durability, and appearance. All materials shall be of tested quality only unless otherwise permitted by the Engineer and/or Consultant. If desired by the Engineer, Test Certificates in respect of each consignment shall be submitted in triplicate. Whenever the materials are required to be used from unidentified stocks, if permitted by the Engineer, a random sample shall be tested at an approved laboratory from each lot of 50 tones or less of any particular section.

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The arc welding electrodes shall be of approved reputed manufacture and conforming to the relevant Indian Standard Codes of Practice and Specifications and shall be of heavily coated type and the thickness of the coating shall be uniform and concentric. With each container of electrodes, the manufacturer shall furnish instructions giving recommended voltage and amperage (Polarity in case of D.C. supply) for which the electrodes are suitable.

All fabricated steel structures and connection materials shall be supplied by the Contractor to the site. The Contractor shall take delivery Horn railway wagons or trucks at site, and unload the materials and perform all formalities like checking of materials and attend to insurance matters as specified in the specifications.

**1.2.5.1 Mild Steel**

- a) Rolled sections and plates up to and including 20mm thickness shall conform to grade 'A' of IS: 2062 and shall be semi-killed. Plates beyond 20mm thickness shall conform to grade 'B' of IS: 2062.
- b) All steel upto and including 40mm thickness shall be in as rolled condition. Plates beyond 40mm thickness shall be normalized and ultrasonically tested.
- c) Rolled sections and plates conforming to IS: 808 and IS: 226 respectively can also be used as available in the stock of the Owner.
- d) Pipes shall conform to IS: 1161.
- e) Hollow (square and rectangular) steel sections shall be hot formed conforming to IS: 4923 and shall be of Grade Yst 240.
- f) Chequered plate shall conform to IS: 3502 and steel shall conform to grade A of IS: 2062.

**1.2.5.2 Medium and High Tensile Steel**

- a) Medium and high tensile steel shall generally conform to grade 'Fe-490B' of IS: 8500, IS: 961 or equivalent.
- b) Rolled sections and plates up to and including 20mm thickness shall be semi-killed and plates beyond 20mm thickness shall be killed.

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c) All steels upto and including 40mm thickness shall be in as rolled condition. Plates beyond 40mm thickness shall be normalized and ultrasonically tested.

**1.2.5.3** All other materials (nuts, lock nuts), consumables etc. shall be as per applicable standards and codes.

**1.2.5.4** In case any defect like laminations is noticed in the steel sections and plates during fabrication and erection, same shall be immediately brought to the notice of the Owner, who shall direct the usage or non-usage of the same. In case of non-usage, the Contractor shall return the same to the Owner's store at his own cost. However, in case of usage, the Contractor shall take necessary precautions such as plug welding etc. and as directed by the Owner, without any extra cost to the Owner.

**1.2.6 Substitution**

**1.2.6.1** If it is found necessary to substitute Indian or imported alternative sections for any of the steel section specified, the written approval of the Owner to the substitution and to the detailed drawing showing the substitution shall be obtained before fabrication is taken up.

**1.2.7 Storage of Materials**

**1.2.7.1 General**

All materials shall be so stored as to prevent deterioration and to ensure their preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged shall be removed immediately from the Contractor's yard, failing which the Owner shall have the liberty to get the material removed and the cost incurred thereof shall be realized from the Contractor. The Contractor shall maintain up to date accounts of receipt, use and balance of all sizes and sections of steel and other materials. In case the fabrication is carried out in Contractors fabrication shop outside the plant site, all materials meant for use in this contract shall be stacked separately with easily identifiable marks.

**1.2.7.2 Yard**

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The Contractor will have to establish a suitable yard in an approved location at site for storing the fabricated steel structures and other raw steel materials such as structural sections and plates as required. The yard shall have facilities like drainage, lighting, and suitable access for large cranes, trailers, and other heavy equipments. The yard shall be fenced all around with security arrangement and shall be of sufficiently large area to permit systematic storage of the fabricated steel structures without overcrowding and with suitable access for cranes, trailers and other equipment for use in erection work in proper sequence in accordance with the approved Programme of work.

The Contractor must visit the site prior to submission of his Bid to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc. all of which shall be carried out by the Contractor at his own cost as directed by the Engineer.

#### **1.2.7.3 Covered Store**

All field connection materials, paints, cement etc. shall be stored on well designed racks and platforms off the ground in a properly covered store building to be built at the cost of the Contractor.

#### **1.2.7.4 Steel**

The steel to be used in fabrication and the resulting cut-pieces shall be stored in separate stacks off the ground, section wise and lengthwise, so that they can be easily inspected, measured and accounted for at any time. If required by the Owner, the materials may have to be stored under cover and suitably painted for protection against weather.

Any steel procured by the Owner other than that of tested quality in accordance with the requirements of Indian Standard obtained either from the main producers or from the open market, shall be marked out separately with paint at ends so that strict control can be exercised in the use of such materials by more frequent tests.

#### **1.2.7.5 Electrodes**

The electrodes for electric arc welding shall be stored in properly designed racks, separating different types of electrodes in distinctly marked compartments. The electrodes shall be kept in a dry and warm condition if necessary by resorting to heating.

#### **1.2.7.6 Bolts, Nuts and Washers**

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Bolts, nuts and washers and other fastening materials shall be stored on racks off the ground with a coating of suitable protective oil. These shall be stored in separate gunny bags or compartments according to diameter, length and quality.

**1.2.7.7 Paints**

Paints shall be stored under cover in airtight containers with adequate fire safety measures. Paints supplied in sealed containers shall be used up as soon as possible once the container is opened.

**1.2.8 Drawings**

**1.2.8.1** The design (scope) drawings shall be supplied by the Owner. The development of the detailed fabrication drawings, on the basis of these design drawings, shall be done by the Contractor.

**1.2.8.2** The detailed drawings (fabrication drawings) shall show complete details including connection / welding / bolting details required for fabrication and erection of structural steel works, all complete, along with their respective bill of materials and design calculation documents.

The fabrication drawings shall include but not limited to the following:

- a) Assembly drawings giving exact sizes of the sections to be used and identification marks of the various sections.
- b) Dimensional drawings of base plates, foundation bolts location etc.
- c) Comparison sheets to show that the proposed alternative section, if any, is as strong as the original sections shown on the Design Drawings.
- d) Complete Bill of Materials and detailed drawings of all sections as also their billing weights.
- e) Any other drawings or calculations that may be required for, the clarification of the works or substituted parts thereof.

"Design Calculation Documents" shall include design of all connections including weld / bolt sizes, brackets, cleats, etc.

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- 1.2.8.3** The detailed fabrication drawings shall be either prepared by the Contractor or by an experienced Specialist Consultant (i.e. an engineering consultancy agency specializing in structural joint / connection design and detailing) engaged by the Contractor for the work. The fabrication drawings shall be duly checked by the Contractor or by the Specialist Consultant before being submitted to the Owner.
- 1.2.8.4** There shall be separate consultants for preparation of fabrication drawings and their checking. The Contractor can either prepare or detail (i.e. be Detailer) or check (i.e. be Checker) the fabrication drawings, provided he has requisite dedicated experienced manpower and expertise to the satisfaction of the Owner. For the other activity, that is other than the activity the Contractor wishes to carry himself (i.e. either Detailer or Checker), he shall engage a Specialist Consultant. In case the Contractor intends to get both preparation and checking of the fabrication drawings done from the outside consultants, then he shall engage two independent Specialist consultants, one for the preparation / detailing of the fabrication drawings (i.e. Detailer) and the other for checking the fabrication drawings (i.e. Checker).
- 1.2.8.5** Depending upon the capacity / capability of the Specialist Consultant engaged by the Contractor, there can be more than one Specialist Consultant, engaged for the purpose of preparation / detailing of fabrication drawings. However, it is intended that for the purpose of checking, there shall be only one agency i.e. the Specialist Consultant (different from the Detailer) or the Contractor himself.
- 1.2.8.6** The Contractor shall engage his own courier / facilities for the collection and distribution of the scope / fabrication drawings and design calculations for the following works, as soon as possible after getting information / intimation.
- a) Collection of scope / design drawings from the Owner on receiving information from the Owner telephonically.
  - b) Distribution of the scope / design drawings to the Detailer on the same day.
  - c) Collection of the fabrication drawings and the design calculations from the Detailer and submission to the Checker, on receiving intimation from the Detailer, regarding readiness of the documents, at various stages.
  - d) Collection of the fabrication drawings and the design calculations from the Checker and submission to the Detailer, on receiving intimation from the Checker, regarding checking of the documents, at various stages.

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e) Submission of the Checker approved fabrication drawings and the design calculations to the Owner.

**1.2.8.7** All fabrication drawings shall be prepared on AutoCAD latest revision, as available on the date of bid opening and submitted to the Owner in both PDF as well as AutoCAD version after checking at their end.

**1.2.8.8** The fabrication drawings shall indicate complete details of fabrication and erection including all splicing details, lacing details, weld sizes and lengths, detailing of all joints, bill of materials, schedule of permanent bolts and all other customary details in accordance with standard structural engineering practice.

**1.2.8.9** The design calculations shall include the design of joints (shear and moment connections), gusset plate, weld calculations viz. size and length of welds, dia. and number of bolts, erection and fabrication splices, shear cleat sizing, stiffener for built-up sections, center to center distance of stiffeners, size of gussets, brackets required for wall beams and other areas etc. in accordance with IS: 800 and other relevant standards.

**1.2.8.10** The fabrication drawings shall indicate identification (erection) marks for purposes of dispatch and erection etc.

**1.2.8.11** In the fabrication drawings, quantities of different sections of structural steel material required shall be indicated. Fabrication drawings shall also give the abstract of quantities for the structures to be painted with different painting systems.

**1.2.8.12** The schedule for permanent bolts and nuts shall show the length, size, weight and numbers required for each fabricated member.

**1.2.8.13** The abstract of quantities (Bill of Material) shall indicate the following as a minimum:

- a) Total weight of the erection mark.
- b) Weight of the erection mark that is to be blast cleaned and applied with red oxide zinc chromate primer and is to be finish painted with synthetic enamel paint of approved shade and colour
- c) Schedule of permanent bolts with their designation, length, numbers and weight.

**1.2.8.14** Each fabrication drawing shall prominently carry the bill of material statement for each section covered in the drawing..

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**1.2.8.15** Whole responsibility for the correctness and completeness of the details shown in the fabrication drawings and design calculations shall lie with the Contractor. In case any modification / dismantling / re-erection is required to be carried out due to incomplete details or mismatch / deficiency in the fabrication drawings and design calculations, the same shall be made good by the Contractor, at his own cost. The cost of any materials (including steel) required for such rectification / modification work shall be borne by the Contractor or else penal recovery at the rates specified under relevant clauses of special conditions of contract shall be applied and recovered. Approval of the design calculations by the Owner shall however not dilute or relieve in any manner, the Contractor of his sole responsibility, for the correctness and completeness of the design calculations and details shown in the fabrication drawings, safety of the structure, good connections, erectability etc.

**1.2.8.16** The fabrication drawings along with the design calculations duly checked and approved by the Checker shall be submitted to the Owner within four (04) weeks of release of scope / design drawings, by the Owner, maintaining strictly the time duration specified here under:

- a) Fabrication drawings and design calculations shall be submitted to the Owner, only after the same has been duly checked and approved by the Checker, and the necessary corrections incorporated. These shall accompany a brief write up prepared by the Checker regarding the comments furnished by him at initial checking stage and as being incorporated by the Detailer in the revised drawings.
- b) If any clarifications are required by the Detailer on the design / scope drawings, the Contractor shall seek such clarification from the Owner, within one (01) week of the release of the design / scope drawing.
- c) Detailer shall submit fabrication drawings and the design calculations to the Checker within two (02) weeks of the release of design / scope drawing.
- d) Checker shall give his comment on the fabrication drawings and the design calculations to the Detailer within three (03) days of his receiving the fabrication drawings and the design calculations from the detailer.
- e) Detailer shall revise the fabrication drawings and the design calculations based on the comments of the Checker and resubmit the same to the Checker, within the next three (03) days of the receipt of the comments.

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- f) Checker shall recheck the fabrication drawings and the design calculations for the comment incorporation, in the next three (03) days of the receipt of the drawing and forward the same after duly approving so as to reach the Owner within next three (03) days. Thus fabrication drawings along with the design calculations duly checked and approved by the Checker are submitted to the Owner within four (04) weeks of the release of scope / design drawings by the Owner.
- g) In case, Checker is different from the Contractor himself the Contractor shall issue necessary authorization to the Checker to directly submit the checked and approved fabrication drawings and the design calculations to the Owner for information / approval.

**1.2.8.17** Owner shall approve the design calculations, either under Cat I / II / III and the fabrication drawings under Cat IV / IVR.

**1.2.8.18** Following shall be categories of approval accorded to the design calculations.

Cat I : Approved without comments.

Cat II : Approved with comments, resubmit.

Cat III : Not approved, to be re-submitted.

**1.2.8.19** Following shall be categories of approval accorded to the fabrication drawings.

Cat IV : For information purposes only.

Cat IVR : To be re-submitted incorporating comments

**1.2.8.20** Six (06) copies of fabrication drawings (with Bill of Material) after being duly checked and approved by the Checker shall be submitted by the Contractor to the Owner.

**1.2.8.21** In case, approval accorded to the design calculations is placed under Cat I by the Owner, then the corresponding fabrication drawings can be considered under Cat IV, provided compatibility of the connection details as per the calculations is ensured in the fabrication drawings. The Detailer shall incorporate all comments / modifications, as noted by the Checker, in the fabrication drawings and furnish six (06) copies of the fabrication drawings (along with the revised Bill of Material), within next three (03) days of his receiving of the Checker's comments, to the Owner.

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- 1.2.8.22** In case, approval accorded to the Design calculations is placed under Cat II by the Owner, then the detailer shall incorporate all comments / modifications, as noted therein and shall revise within next three (03) days and re-submit through the Checker, four (04) copies of the revised fabrication drawings (with revised bill of material) along with the revised design calculations, within next seven (07) days of his receiving the Owner's comments, to the Owner, for his approval.
- 1.2.8.23** In case, approval accorded to the design calculations is placed under cat III by the Owner, the detailer shall incorporate all comments / modifications, as noted therein and shall revise thoroughly within next five (05) days and re-submit through the Checker, four (04) copies of the revised fabrication drawings (with revised bill of material) along with the revised design calculations, within next ten (10) days of his receiving the Owner's comments, to the Owner, for his approval.
- 1.2.8.24** In case, approval accorded to the fabrication drawings is placed under Cat IV by the Owner and to the design calculations is placed under Cat I by the Owner, then the Contractor shall submit six (06) number of fabrication drawings and three (03) number of design calculation to the Owner at site, within next three (03) days of the approval.
- 1.2.8.25** The Contractor shall also furnish to the Owner two (02) hard copies and one soft copy both for the design calculations (approved under Cat I) and the fabrication drawings with Bill of Material (approved under Cat IV) on CDs or any other electronic media, as approved by the Owner. The Contractor shall further submit to the Owner at site two hard copies and one soft copy of the as-built / as-fabricated fabrication drawing on CDs or any other electronic media, as approved by the Owner. Soft copy of as-built / as-fabricated fabrication drawings shall be made by the Contractor by scanning the as-built / as-fabricated fabrication drawings, in which all the changes made at site and the approval by the site Owner have been incorporated.
- 1.2.8.26** If it is found necessary to substitute alternative sections for any of the steel sections specified, a written approval of the Owner for the substitution, shall be obtained by the Contractor and details of all such substitution, as duly approved by the Owner shall be incorporated in the as-built fabrication drawings.
- 1.2.8.27** The scope / design drawings may require revisions either before or after the preparation and approval of fabrication drawings and design calculations. The design drawings may also be released with holds, which are to be released subsequently. Such revisions and release of holds shall be duly incorporated by the Contractor at his own cost, in the fabrication drawings and design calculations already finalised and re-submit to the Owner, after getting them duly checked by the Checker. The Contractor is expected to

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make his own assumptions regarding the quantum of such revisions involving preparation / revision / checking of design calculations / fabrication drawings.

**1.2.9 Design of Connections**

**1.2.9.1** All connections shall generally be done through welding, unless otherwise specified in the design / scope drawings. Bolts when used for connections shall be of mild steel, high strength steel and / or friction grips, as indicated in the scope / design drawings.

**1.2.9.2** Fabrication drawings and design calculations shall be prepared according to the provision of IS: 800, IS: 816, IS: 1367, IS: 3757, IS: 4000, IS: 9178 and IS: 9595.

**1.2.9.3** Connection of vertical bracing with connecting members and diagonals of truss members shall be designed for full tensile capacity of the bracing, unless actual loads are indicated on the design / scope drawings.

**1.2.9.4** Size of fillet weld for flange to web connection for built-up section shall be as follows: -

- a) For box section weld size shall be designed for full shear capacity or actual shear if indicated in design / scope drawings, whichever is more. Wherever fillet weld is not possible, full strength full penetration butt weld shall be provided.
- b) For built-up plated I-section, weld size shall be designed for 80% of full shear capacity or actual shear, if indicated in design / scope drawings, whichever is more. However, weld size shall not be less than 0.5 times the web thickness. Weld shall be of double fillet.
- c) All structural welds shall be continuous and the minimum size of the Fillet weld shall be 6mm.

**1.2.9.5** Erection bolts shall be provided to hold the steel members in position during erection and alignment.

**1.2.9.6** Shear connections shall be designed for 65% of section strength for rolled sections and 80% of section strength for built-up plated I-section or combination of rolled section with cover plates. However, if the load actually applied is more than the above-specified value, the connection shall be designed for actual applied load.

**1.2.9.7** Moment connections between beam and column shall be designed for 100% of moment capacity of the beam section. This can be achieved either by direct butt welding of the

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top flange of beam with column flange or by providing top moment plate with suitable notch for additional weld length, as directed by the Owner.

- 1.2.9.8** All butt welds shall be of full strength full penetration butt welds.
- 1.2.9.9** Connection between top flange and web of crane girder shall be of full penetration butt weld. Bottom flange connection with web can be of fillet weld or butt weld, as directed by Owner.
- 1.2.9.10** Connection of base plate and associated stiffeners with the columns shall be designed considering the total load transferred through welds. However, the minimum weld size (double fillet) shall not be less than 0.6 times the thickness of stiffeners.
- 1.2.10 Splicing**
- 1.2.10.1** All splicing works shall be for full strength.
- 1.2.10.2** Field splicing shall be done with web/flange cover plates. For exceptional cases the field splicing will be designed for 50% of load carried by the cover plates and remaining 50% load through full penetration butt weld. Shop splicing of all plates shall be carried out by full strength - full penetration butt welds. Shop splicing for all rolled sections (beams, channels, angles, hollow sections, etc.) shall be carried out using web and flange cover plates. Shop splicing for solid round sections shall be done by combination of butt weld and stiffening (splice) plates.
- 1.2.10.3** Field splicing of built-up section is generally not envisaged. However it can be provided only in exceptional cases, if indicated in the scope / design drawings, with butt weld followed by splice cover plates. Splice cover plates shall be designed for the full strength.
- 1.2.10.4** In case any additional splices are needed than those indicated in the design / scope drawings by the Contractor, on account of limitation of crane (Le. by not mobilizing crane of specified capacity), then the same can be provided subject to a maximum penal recovery of steel sections used for such additional splicing, at the rates specified for reconciliation of structural steel consumption under relevant clauses of special conditions of contract.

**1.3.0 CODES AND STANDARDS**

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- 1.3.1** All applicable Standards, Specifications, Acts and Codes of Practice referred to herein shall be the latest editions including all applicable official amendments and revisions. A complete set of all such documents, shall generally be available at site, with the Contractor.
- 1.3.2** In case of conflict between this Specification and those (IS Standards, Codes etc.) referred to herein in the subsequent article, the former shall prevail.
- 1.3.3** Some of the relevant applicable Indian Codes, Standards and Acts are referred to herein below:

**a) Materials**

1. IS: 226 Structural steel (Standard Quality)
2. IS: 808 Dimensions for Rolled Steel Beam, Column, Channel and Angle Sections.
3. IS: 814 Covered Electrodes for Manual Metal Arc Welding of Carbon and Carbon Manganese Steel.
4. IS: 815 Classification and coding of covered electrodes for metal arc welding of structural steels
5. IS: 961 Structural Steel (High Tensile)
6. IS: 1148 Rivet bars for structural purposes
7. IS: 1149 High tensile rivet bars for structural purposes
8. IS: 1161 Steel Tubes for structural purposes.
9. IS: 1239 Mild Steel Tubes
10. IS: 1363 Hexagon Head Bolts, Screws and Nuts of Product Grade C.
11. IS: 1364 Hexagon Head Bolts, Screws and Nuts of Product Grades A and B.
12. IS: 1367 (Part I,II) Technical supply conditions for Threaded Steel Fasteners
13. IS: 1367 Part – 3 Mechanical Properties and Test Methods For Bolts, Screws and Studs With full loadability
14. IS: 1367 Part – 6 Mechanical Properties and Test Methods For Nuts with Specified Proof Load.
15. IS: 1367 Part – 9 Surface discontinuities on Bolts. (Sections 1 and 2)
16. IS: 1367 Part – 13 Hot Dip Galvanized Coating on Threaded Fasteners.

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17. IS: 1442 Covered electrodes for the metal arc welding of high tensile structural steel
18. IS: 1852 Specification for Rolling and Cutting Tolerances for Hot Rolled Steel Products.
19. IS: 1977 Structural steel (ordinary quality) St-42-0
20. IS: 2016 Specification for Plain Washers.
21. IS: 2062 Steel for General Structural Purposes.
22. IS: 2074 Ready mixed paint, red oxide Zinc chromate priming
23. IS: 3063 Specification of Single Coil Rectangular Section Spring Lock Washers for Bolts, Nuts and Screws.
24. IS: 3502 Specifications for Steel Chequered Plates.
25. IS: 3757 Specification for High Strength Structural Bolts.
26. IS: 4218 Specification for ISO Metric Screw Threads.
27. IS: 4923 Specification for Hollow Steel Sections for Structural use.
28. IS: 5369 General requirements for Plain Washers and Lock Washers.
29. IS: 5624 Specification for Foundation Bolts.
30. IS: 6623 Specification for High Strength Structural Nuts.
31. IS: 6639 Specification for Hexagon Bolts for Steel Structures.
32. IS: 6649 Specification for Hardened and Tempered Washer for High Strength Structural Bolts and Nuts.
33. IS: 6911 Specification for Stainless Steel Plate, Sheet and Strip.
34. IS: 7280 Bare wire electrodes for submerged arc welding of structural steels.
35. IS: 8500 Specification for Structural Steel Micro-Alloyed (Medium and high Strength qualities).
36. IS: 13238 Specification for Epoxy Based Zinc Silicate Primer (Two Pack).
37. IS: 13239 Epoxy Surfacer (Two Pack).
38. IS: 13467 Chlorinated Rubber for Paints.
39. IS: 14209 Epoxy Enamel Two Component Glossy.

**b) Codes of Practice**

1. IS: 800 Code of Practice for General Construction in Steel.
2. IS: 806 Rolled steel beams, channels, and angle sections
3. IS: 813 Scheme of symbols for welding.
4. IS: 816 Code of Practice for Use of Metal Arc Welding for

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- General Construction in Mild Steel.
5. IS: 817 Code of Practice for Training and Testing of Metal Arc Welders.
  6. IS: 818 Code of practice for safety and health requirements in electric and gas welding and cutting operations
  7. IS: 822 Code of practice for inspection of welds
  8. IS: 919 Recommendations for limits and fits for Engineering
  9. IS: 1024 Code of Practice for Use of welding in Bridges and structures subject to Dynamic Loading.
  10. IS: 1477 Code of Practice for Finishing of Ferrous Metals in Buildings - Painting and Allied Finishes.
  11. IS: 1730 Dimensions for steel plate, sheet, and strip for structural and general engineering purposes
  12. IS: 1731 Dimensions for steel flats for structural and general engineering purposes
  13. IS: 2629 Recommended Practices for Hot Dip Galvanising of Iron and Steel.
  14. IS: 2811 Recommendations for Manual Tungsten Inert Gas Arc Welding of Austenitic Stainless Steel.
  15. IS: 3696 Safety Code of Scaffolds and Ladders.
  16. IS: 4000 Code of Practice for High Strength Bolts in Steel Structure.
  17. IS: 4353 Recommendations for Submerged Arc welding of Mild Steel and Low Alloy Steels
  18. IS: 4759 Hot Dip Zinc Coatings on Structural Steel and Other Allied Products.
  19. IS: 5206 Covered Electrodes for Manual Metal Arc Welding of Stainless Steel and other similar High Alloy Steels.
  20. IS: 7205 Safety Code for Erection of Structural Steelwork.
  21. IS: 7215 Tolerances for Fabrication of Steel Structures.
  22. IS: 7293 Safety Code for working with Construction Machinery.
  23. IS: 7318 Fusion Welding of Steel-Approval Test for Welders.
  24. IS: 9178 Criteria for Design of Steel Bins for Storage of Bulk Materials.
  25. IS: 9595 Recommendations for Metal Arc Welding of Carbon and Carbon-Manganese Steels.
  26. IS: 12843 Tolerances for Erection of Steel Structures.
  27. SP : 6 ISI Hand Book for Structural Engineers.
- Parts 1 - 7

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28. ISO: 898/2 Mechanical Properties of Nuts.
29. ISO: 3269 Fasteners - Acceptance Inspection.

**c) Standards for Testing**

1. IS: 228 Methods of Chemical Analysis of Steels.
2. IS: 1181 Qualifying Tests for Metal Arc Welders (Engaged in welding structures other than Pipes).
3. IS: 1182 Recommended Practice for Radiographic Examination of Fusion Welded Butt Joints in Steel Plates.
4. IS: 1200 Method of measurement of steelwork and ironwork (Part 8)
5. IS: 1599 Method of Bend Test.
6. IS: 1608 Mechanical Testing of Metals - Tensile Testing.
7. IS: 1852 Specifications for Rolling and Cutting Tolerances for Hot-rolled Steel Products
8. IS: 2595 Code of Practice for Radiographic Testing.
9. IS: 2614 Methods for Sampling of Fasteners.
10. IS: 2633 Method for testing uniformity of coating on Zinc Coated Articles
11. IS: 3613 Acceptance Tests for Wire Flux Combination for Submerged Arc Welding.
12. IS: 3658 Code of Practice for Liquid Penetrant Flaw Detection.
13. IS: 3664 Code of Practice for Ultrasonic Pulse Echo Testings by Contact and immersion methods.
14. IS: 5334 Code of Practice for Magnetic Particle Flaw Detection of Welds.
15. IS: 6821 Methods for Sampling of Non Threaded Fasteners.
16. IS: 7307 Approval Test for welding Procedures.  
Part - 1: Fusion welding of Steel.
17. IS: 7310 Approval Test for Welders working to approved welding  
Part - 1: Procedure: Fusion welding of Steel.

**1.4.0 TECHNICAL REQUIREMENTS – INSTALLATION**

**1.4.1 Fabrication**

**1.4.1.1 Site Fabrication**

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The fabrication of works shall be carried out generally in accordance with IS: 800 as well as with the stipulations contained in these specifications. IS: 9178 (Parts I and II) shall be followed as general guidance for fabrication and erection of bins / silos. All structures shall be completely site fabricated, in the fabrication / pre-assembly yard developed by the Contractor, at his own cost, within the project site.

**1.4.1.2 Identification of Material**

Fabricated components shall be traceable to material test certificates and shall be capable of positive identification at different stages of fabrication. During fabrication, upto the point of assembling members, each piece of high strength steel shall carry fabricators identification mark.

**1.4.1.3 Collection of Steel**

The Owner shall issue steel to the Contractor from their project stores. Contractor shall make all arrangements, whatsoever required for the collection, loading, weighing, transportation, protection against damage in transit, unloading and storage of steel, reconciliation and return of surplus / waste steel to the Owner's stores, etc. all complete.

**1.4.1.4 Straightening**

Rolled materials before being laid off or worked, must be clean, free from sharp kinks, bends or twists and straight within the tolerances allowed by the Indian Standard Specification on IS: 1552 - Specification for rolling and cutting tolerance for hot-rolled steel products. If straightening is necessary, it may be done by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 600° C.

**1.4.1.5 Cutting**

The Contractor shall prepare necessary cutting plans for all fabrication work taking into consideration the availability of materials and cut pieces generated during the work with the object of minimizing wastage. Care shall be taken by the Contractor to ensure maximum utilization of cut pieces and if required by providing additional butt weld, at his own cost.

Shearing, cropping, or sawing shall affect cutting. Use of a mechanically controlled gas-cutting torch may be permitted for mild steel only. Gas cutting of high tensile steel may

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also be permitted provided special care is taken to leave sufficient metal to be removed by machining, so that all metal that has been hardened by flame is removed. Gas cutting without a mechanically controlled torch may be permitted if special care is taken and done under expert hand, subject to the approval of the Engineer.

To determine the effective size of members cut by gas, 3 mm shall be deducted from each cut edge. Gas cut edges, which will be subjected to substantial stress or which are to have weld metal deposited on them, shall be reasonably free from gouges, occasional notches or gouges not more than 4 mm deep will be permitted. Gouges greater than 4 mm that remain from cutting shall be removed by grinding. All re-entrant corners shall be shaped notch free to a radius of at least 12 mm. Shearing, cropping and gas cutting shall be clean, reasonably square and free from any distortion.

#### **1.4.1.6 Planning of Edges**

Planning or finishing of sheared or cropped edges of plates or shapes or of edges gas-cut with a mechanically controlled torch shall not be required, unless specifically required by design and called for on the drawings, included in a stipulation for edge preparation for welding or as may be required after the inspection of the cut surface. Surface cut with hand-flame shall generally be ground, unless specifically instructed otherwise by the Engineer.

#### **1.4.1.7 Bending and Rolling**

Bending of plates and rolled sections to the specially required shapes for fabrication shall be done on plate bending machine or by cold bending process without resorting to heating, hammering, angle smithy and black smithy process.

#### **1.4.1.8 Grinding**

- All the edges cut by flame shall be ground before they are welded.
- Ends of all bearing stiffeners shall be machined or ground to fit tightly at both top and bottom. The maximum permissible gap between the bearing stiffeners and the flanges shall not be more than 0.2 mm locally.
- In case of crane / gantry girder, the bottom of the knife-edge support shall be accurately ground to provide effective bearing on the column bracket with a clearance not exceeding 0.2 mm locally at any place. The top surface of the column bracket shall also be ground similarly. The column splices and butt joints of struts and compression members shall be accurately ground and closely butted over the

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whole section with tolerance not exceeding 0.2 mm locally at any place. Notwithstanding the above, full load shall be transferred through the welds.

- d) The ends of column shafts together with attached gussets, stiffeners, angles, channels, etc. after welding together shall be accurately ground, so that the parts connected butt over the entire surface of contact.
- e) The column base slabs shall be similarly ground over the bearing surface and shall have effective contact with the end of the shaft. The bearing face that is to be grouted direct to a foundation need not be ground.

#### **1.4.1.9 Clearances**

The erection clearance for cleat ends of members connecting steel to steel shall not be greater than 2mm at each end, unless approved by the Owner.

The erection clearance for cleated ends of members connecting steel to steel shall preferably be not greater than 2 mm at each end. The erection clearance at ends of beams web shall be not more than 3 mm at each end, but where for practical reasons greater clearance is necessary, suitably designed cleatings shall be provided.

#### **1.4.1.10 Riveted and Bolted Construction**

##### **a) Holes**

Holes through more than one thickness of material for members, such as compound stanchions and girder flanges, shall be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, if the thickness of the material is not greater than the nominal diameter of rivet or bolt plus 3 mm subject to a maximum thickness of 16 mm provided that the holes are punched 3 mm less in diameter than the required size and reamed after assembly to the full diameter.

Holes for rivets or black bolts shall be not more than 1.5 mm or 2.0 mm (depending on whether the diameter of the rivet or bolt is less or more than or equal to 25 mm) larger in diameter than the nominal diameter of the rivet or black bolt passing through them.

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Holes for turned and fitted bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to a tolerance grade of BS as specified in IS: 919. Parts to be connected shall be firmly held together by tacking welds or clamps and the holes drilled through all the thickness in one operation and subsequently reamed to size. Holes not drilled through all thickness in one operation shall be drilled to a smaller size and reamed out after assembly.

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

**b) Assembly**

All parts of riveted members shall be well pinned or bolted and rigidly held together while riveting. Drifting to enlarge un matching holes shall not generally be permitted. In case drifting is permitted to a slight extent- during assembly, it shall not distort the metal or enlarge the holes. Holes that must be enlarged to admit the rivets or bolts shall be reamed. Poor matching of holes shall be cause for rejection .The component parts shall be so assembled that they are neither twisted not otherwise damaged, and shall be so prepared that the specified cambers, if any, are maintained.

Rivets shall ordinarily be hot driven, in which case their finished heads shall be approximately hemispherical in shape and shall be of uniform size throughout the work for rivets of the same size full, neatly finished and concentric with the holes. Rivets shall be heated uniformly to a temperature not exceeding 1125° C they shall not be driven after their temperature has fallen below 540° C.

Rivets shall be driven by power riveters, of either compression or manually operated type, employing pneumatic, hydraulic or electric power. Hand driven rivets shall not be allowed unless in exceptional cases specifically approved by the Engineer. After driving, rivets shall be tight, shall completely fill the holes and their heads shall be in full contact with the surface. In case of countersunk rivets, the countersinking shall be fully filled by the rivet, any roughness of the countersunk head being dressed off flush, if required.

Riveted members shall have all parts firmly drawn and held together before and during riveting and special care shall be taken in this respect for all single riveted connections. For multiple riveted connections, a service bolt shall be provided in every third or fourth hole.

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All loose, burnt, or otherwise defective rivets shall be cut out and replaced and special care shall be taken to inspect all single riveted connections. Special care shall also be taken in heating and driving long rivets. The Contractor shall prove the quality of riveting by cutting some rivets chosen at random by the Engineer. No extra payment will be made to the Contractor for such cutting and replacing. Riveting Work, for any particular section or group, will be considered satisfactory when at least 90% of the corresponding cut rivets is found to be sound. If the ratio is below 75%, all the rivets in the particular section or group shall be cut, removed and replaced and tested again at the Contractor's expense. For cases between 75% and 90% the engineer shall have the option to instruct cutting and replacing any number of further rivets at the Contractor's cost as he deems necessary.

Bolted construction shall be permitted only in case of field connections if called for on the Drawings and is subjected to the limitation of particular connections as may be specified. In special cases, however, shop bolt connections may be allowed if shown on drawing or directed by the Engineer.

Washers shall be tapered or otherwise suitably shaped, where necessary, to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project through the nut at least one thread. In all cases the bolt shall be provided with a washer of sufficient thickness under the nut to avoid any threaded portion of the bolt being within the thickness of the parts bolted together. In addition to the normal washer one spring washer or lock nut shall be provided for each bolt for connections subjected to vibrating forces or otherwise as may be specified on the Drawings.

The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged and shall be so prepared that the specified camber, if any is provided. If the individual components are to be bolted, parallel and tapered drifts shall be used to align the parts so that the bolts can be accurately positioned.

Items like roof trusses, galleries, bunkers / hoppers, etc. shall be trial assembled keeping in view the actual site conditions, prior to dispatch to site for erection so that they can be conveniently pre-assembled before erection or conveniently pre-assembled during erection. Necessary match marks shall be made on these components before disassembly in the shop and dispatching.

For columns which are fabricated in two or more parts, controlled / trial assembly shall be carried out in the pre assembly / fabrication yard before dispatch to the erection Site.

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**c) Bolting**

- a) Bolting will involve the provision of bolts in clearance holes and / or high strength friction grip fasteners.
- b) The diameter of the bolt hole shall be taken as the nominal diameter of the bolt plus 1.5mm, unless noted otherwise.
- c) Every bolt shall be provided with a washer under the nut so that no part of the threaded portion of the bolt is within the thickness of the parts bolted together.
- d) Flat washers shall be circular of a diameter 2.5 times that of bolt and of suitable thickness. Where bolt heads / nuts bear upon the beveled surfaces they shall be provided with the square tapered washers of suitable thickness to afford a seating square with the axis of the bolt as per satisfaction of Owner.
- e) All bolts and nuts shall be of steel, with well-formed hexagonal heads. The nuts shall be good fit on the bolts and minimum two clear threads shall show through the nut when it has been finally tightened up.
- f) Notwithstanding anything to the contrary contained in IS: 1363, IS: 1364, and IS: 1367, the unthreaded length of the bolt shall be equal to total thickness of metal being bolted together plus 2mm. The threaded length shall be equal to at least the diameter of bolt plus 6mm.
- g) IS: 4000 shall be followed for high strength friction grip fasteners.

**1.4.1.11 Notches**

The ends of all joints, beams and girders shall be cut truly square unless required otherwise and joist flanges shall be neatly cut away or notched where necessary, the notches being kept as small as possible.

**1.4.1.12 Machining of Butts, Caps and Bases**

- a) 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 0.1 mm locally at any place if the welds are not designed to transmit the entire loading. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels, etc., after

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welding together should be accurately machined so that the parts connected butt over the entire surfaces of contact. Care should be taken that these gussets, connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 1.0mm. Where sufficient gussets or welds are provided and specifically designed to transmit the entire loading and are indicated in the drawing, the column ends need not be machined.

- b) Slab Bases and Caps - Slab bases and slab caps, except when cut from material with true surfaces, shall be accurately machined over the bearing surfaces and shall be in effective contact with the end of the column. A bearing face which is to be grouted direct to a foundation need not be machined if such face is true and parallel to the upper face.
- c) To facilitate grouting, holes shall be provided where necessary in column bases for the escape of air.

#### **1.4.1.13 Lacing Bars**

The ends of lacing bars shall be neat and free from burns.

#### **1.4.1.14 Separators**

Rolled section or built-up steel separators or diaphragms shall be required for all double beams except where encased in concrete, in which case, pipe separators shall be used.

#### **1.4.1.15 Bearing Plates**

Provision shall be made for all necessary steel bearing plates to take up reaction of beams and columns and the required stiffeners and gussets whether or not specified in Drawings.

#### **1.4.2 Welding**

**1.4.2.1** The works shall be done as per approved fabrication drawing which would clearly indicate various details of joints to be welded, type of weld, length and size of weld, whether shop or site weld.

**1.4.2.2** Welding of structural steel shall be done by an electric arc process, submerged arc welding / MIG welding / manual metal arc welding. Welding shall conform generally to relevant acceptable standards viz. IS: 816, IS: 9595, IS: 814, IS: 1024, IS: 4354 and Indian Standard hand book for metal arc welding, and other standards, codes of practice

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internationally accepted. For welding of any particular type of joint, Contractor shall give evidence acceptable to the Owner of having satisfactorily completed appropriate tests as described in any of the Indian Standards - IS: 817, IS: 7307 and international standard as relevant.

- 1.4.2.3** Welding process employing semi-automatic welding machine and / or MIG welding and / or fully automatic welding machine shall be used for welding longitudinal fillet welds (connecting flange with web) and butt joints for fabrication of columns, framing beams and crane/gantry girders, unless manual arc welding is specifically approved by the Owner. Necessary jigs and fixtures and rotation of structural shall be so arranged that vertically down-hand position of welding becomes possible. 'open-arc-welding' process employing coated electrodes shall be employed for fabrication of other welded connections and field welding.
- 1.4.2.4** Wherever welding is done for assembling the components of structural, the job shall be so positioned that down-hand welding is possible.
- 1.4.2.5** Any structural joint shall be welded only by those welders who are qualified for all welding procedures and positions required in such a joint.
- 1.4.2.6** The Contractor shall maintain records of all the welders identification marks, the joints welded by each welder, the welding procedure adopted, welding machine employed, pre and post heating done and any non-destructive test done and stress relieving / heat treatment performed on such joints. All such records for entire welding operation shall be accessible to the Owner at all times for scrutiny.
- 1.4.2.7** In fabrication of plated columns / 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. Wherever weld reinforcement interferes with proper fitting between components to be assembled for welding, these welds shall be ground flush prior to assembly.
- 1.4.2.8** The members to be joined by fillet welding shall be brought and held as close together as possible and in no event shall be separated by more than 4mm. If the separation is 1.5mm or greater, the fillet weld size shall be increased by the amount of separation.
- 1.4.2.9** The bins / silos shall be made of mild steel plates joined together with full strength butt weld and provided with stiffeners at regular intervals. Stiffeners shall be welded on the external face.

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### **1.4.3 Electrodes**

**1.4.3.1** The electrodes used for welding shall be of suitable type and size depending upon specifications of the parent material, the method of welding, the position of welding and quality of welds desired. Only low hydrogen electrodes shall be used for welding of medium / high tensile steel and for mild steel plate thickness above 20 mm.

**1.4.3.2** All low hydrogen electrodes shall be baked and stored before use as per manufacturer's recommendation. The electrodes shall be re-baked at 250°C - 300°C for one hour and later on cooled in the same oven to 100° C. It shall be transferred to a holding oven maintained at 60°C - 70°C. The electrodes shall be drawn from this oven for use.

**1.4.3.3** Where coated electrodes are used they shall meet the requirements of IS: 814 and relevant ASME-Sec II. Covering shall be heavy to withstand normal conditions of handling and storage.

**1.4.3.4** Only those electrodes that give radiographic quality welds shall be used for welds, which are subjected to radiographic testing.

**1.4.3.5** Where bare electrodes are used these shall correspond to specification of the parent material. The type of flux-wire combination for submerged arc welding shall conform to the requirements of IS: 3613 and F-60 class of AWSA-5-17-69. The electrodes shall be stored properly and the flux shall be baked before use in an oven in accordance with the manufacturer's requirements as stipulated.

**1.4.3.6** The Contractor shall take specific approval of the weld for the various electrodes proposed to be used on the works before any welding is started.

### **1.4.4 Edge Preparation for Welding**

**1.4.4.1** Suitable edge as per weld joint detail shall be prepared either by machines or by automatic gas cutting. All edges cut by flame shall be ground before they are welded.

### **1.4.5 Pre Heating and Post Heating**

**1.4.5.1** Mild steel and medium / high tensile steel plates thicker than 20mm, will require Pre-Heating of the parent plate prior to welding as mentioned in Table - 1 for mild steel and Table - 2 for medium / high tensile steel, however, higher pre heat temperature may be required as per approved welding procedure and it shall be followed. In welding materials of unequal thickness, the thicker part shall be taken for this purpose.

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- 1.4.5.2** Base metal shall be preheated, notwithstanding provisions of IS: 9595 to the temperature given in Table - 1 for mild steel and Table - 2 for medium / high tensile steel, prior to welding or tack welding. When base metal not otherwise required to be pre heated, is at a temperature below 0°C, it shall be pre heated to at least 20°C., prior to tack welding or welding. Pre heating shall bring the surface of the base metal to the specified pre heat temperature and this temperature shall be maintained as minimum inter-pass temperature while welding is in progress.

**TABLE – 1  
MINIMUM PREHEAT AND INTER-PASS TEMPERATURE FOR WELDING  
MILD STEEL**

Thickness of thicker part at Point of welding	Welding Using	
	Low hydrogen electrode or submerged arc welding	Other than low hydrogen electrode
Upto and including 20mm	None	None
Over 20mm and upto and including 40mm	20°C	Not allowed
Over 40mm and upto and including 63mm	66°C	Not allowed
Over 63mm	110°C	Not allowed

Note: Type of electrode and the preheating requirements for welding shall be as per approved welding procedure.

**TABLE – 2  
MINIMUM PREHEAT AND INTER-PASS TEMPERATURE FOR WELDING  
MEDIUM / HIGH TENSILE STEEL**

Thickness of thicker part at Point of welding	Welding Using	
	Low hydrogen electrode or submerged arc welding	Other than low hydrogen electrode
Upto and including 20mm	None	Not allowed
Over 20mm	120°-140°C	Not allowed

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Note: Type of electrode and the preheating requirements for welding of medium and high tensile steel shall be as per approved welding procedure.

- 1.4.5.3** Pre heating may be applied by external flame which is non-carbonizing like LPG, by electric resistance or electric induction process such that uniform heating of the surface extending up to a distance of four times the thickness of the plate on either side of the welded joint is obtained.
- 1.4.5.4** Thermo-chalk, thermo-couple or other approved methods shall be used for measuring the plate temperature.
- 1.4.5.5** All butt welds with plates thicker than 50mm and all site butt welds of main framing beam supporting the bunker shall require post weld heat treatment as per procedure given in AWS D-1.1. Post heating shall be done up to 600°C and rate of application shall be 200°C per hour.
- 1.4.5.6** The post heat temperature shall be maintained for 60 minutes per 2.5cm thickness. For maintaining slow and uniform cooling, asbestos pads shall be used for covering the heated areas.
- 1.4.6 Welding Sequence**
- 1.4.6.1** The sequence of welding shall be carefully chosen to ensure that the components assembled by welding are free from distortion and large residual stresses are not developed. The distortion should be effectively controlled either by a counter effect or by a counter distortion.
- 1.4.6.2** The direction of welding should be away from the point of restraint and towards the point of maximum freedom.
- 1.4.6.3** Each case shall be carefully studied before finally following a particular sequence of welding.
- 1.4.6.4** Butt weld in flange plates and / or web plates shall be completed before the flanges and webs are welded together.
- 1.4.6.5** The beam and column stiffeners shall preferably be welded to the webs before the web and flanges are assembled unless the web and flanges of the beam or column are assembled by automatic welding process.

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- 1.4.6.6** All welds shall be finished full and made with correct number of runs, the welds being kept free from slag and other inclusions, all adhering slag being removed from exposed faces immediately after such run.
- 1.4.6.7** Current shall be appropriate for the type of electrode used. To ensure complete fusion, the weaving procedure should go proper and rate of arc advancement should not be so rapid as to leave the edges unmelted.
- 1.4.6.8** Puddling shall be sufficient to enable the gases to escape from the molten metal before it solidifies.
- 1.4.6.9** Non-uniform heating and cooling should be avoided to ensure that excessive stresses are not locked up resulting ultimately in cracks.
- 1.4.6.10** The ends of butt welds shall have full throat thickness. This shall be obtained on all main butt welds by the use of run off and run on pieces adequately secured on either side of main plates. The width of these pieces shall not be less than the thickness of the thicker part joined. Additional metal remaining after the removal of extension pieces shall be removed by grinding or by other approved means and the ends and surface of the welds shall be smoothly finished. Where the abutting parts are thinner than 20mm the extension pieces may be omitted but the end of the butt welds shall then be chipped or gouged out to sound metal and side welded to fill up the ends to the required reinforcement.
- 1.4.6.11** The fusion faces shall be carefully aligned. Presetting shall control Angle shrinkage. Correct gap and alignment shall be maintained during the welding operation.
- 1.4.6.12** All main butt welds shall have complete penetration and back surface of the weld being gouged out clean before first run of the weld is given from the back. However, partial penetration butt weld shall be permitted, when specifically shown in the fabrication drawings.
- 1.4.6.13** Intermittent welds shall be permitted only when specifically approved in the fabrication drawings.
- 1.4.6.14** The welding shrinkage shall be minimised by adopting the correct welding procedure and method. In long and slender member, extra length should be provided at the time of fabrication to account for shrinkage.

**1.4.7 Testing and Qualification of Welders**

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**1.4.7.1** On the basis of the welding procedure, the Contractor shall conduct qualification test. All the welders to be employed for the job shall have to qualify the appropriate tests laid down in IS: 817 and IS: 1181 and ASME IX / AWS D1.1.

**1.4.7.2** All necessary arrangements required for the testing and qualification of welders are to be provided by the Contractor.

**1.4.8 Inspection of welds**

**1.4.8.1 Visual Inspection**

100 % of the welds shall be inspected visually for external defects. Dimensions of welds shall be checked. The lengths and size of weld shall be as per approved fabrication drawings. It may be slightly oversized but should not be undersized. The profile of weld is affected by the position of the joint but it should be uniform. The welds should have regular height and width of beads. The joints in the weld run shall as far as possible be smooth and should not show any humps or craters in the weld surface. Welds shall be free from unfilled craters on the surface, under-cuts, slags on the surface and visible cracks. Such inspection shall be done after cleaning the weld surface with steel wire brushes and chisels to remove the spatter metal, scales, slag etc. If external defects mentioned above are noticed, there is every possibility of internal defects and further radiographic/ultrasonic examination shall be undertaken as per Indian Standards. Weld gauges shall be used to measure the size of the welds.

**1.4.8.2 Mechanical testing**

Test plates shall be incorporated on either side of at least one main butt weld of each flange plate and web plate of every main frame column. The weld shall be continuous over the test plate. The test plate shall be cut from extensions of the main plates and shall be fixed so that metal lies in the same direction as that of the main plate. Test plates shall be prepared and tested in accordance with the accepted Standards, in the presence of the Owner or his authorised representative. All testing equipment and facilities for carrying out these tests shall be provided by the Contractor. If any of these tests fail, further radiographic examination of the welds in question on the main members, shall be undertaken by the Contractor. These tests for the test plates and radiographic examination are additional to those contemplated under routine inspection and testing. The Contractor shall carry out these additional radiographic tests as per normal testing procedure.

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### **1.4.8.3 Non-destructive and special testing**

In addition to the normal supervision and testing procedure, radiographic / ultrasonic or other non-destructive examination shall be carried out as stipulated on butt or fillet welded joints and/ or on test specimens, as per applicable standards. All test of welds shall be carried out by the Contractor at his own cost as per applicable standards. However, for checking the quality of weld, the Owner shall carry out additional tests at his own cost. The Contractor shall provide necessary supporting facilities free of cost, as may be required by the Owner, including cordoning of radiation zone while Radiography testing is in progress. Prepared etched section of the welds may be required for examination. The Contractor shall, provide these prepared sections, at his own cost.

In case of failure of any of the tests, rectification of such components shall also be carried out by the Contractor at his own cost. Retesting of the rectified joint, shall also be carried out by the Contractor at his own cost.

### **1.4.9 Rectification And Correction**

**1.4.9.1** Wherever defects like improper penetration, extensive presence of blow holes, undercuts, cracking, slag inclusion, etc. are noticed by visual Inspection / other tests, the welds, in such location shall be removed by gouging process. The joints shall be prepared again by cleaning the burrs and residual matters with wire brushes and grinding, if necessary, and re-welded. The gouging shall as far as possible be done using gouging electrodes.

### **1.4.10 Correction of Defective welds**

**1.4.10.1** Correction of defective welds shall be carried out as directed by Owner without damaging the parent metal. When a crack in the weld is removed, Magnetic Particle Inspection (MPI) or any other equally positive means shall be used to ensure that the whole of the crack and the material up to 25mm beyond each end of the crack has been removed. Cost of all such tests and operation incidental to correction shall be to Contractor's account.

### **1.4.11 Acceptance of Welded Structures**

**1.4.11.1** The acceptance of the welded work shall depend upon correct dimensions and alignment, absence of distortion in the structure, satisfactory results from the inspection and testing of the joints and the test specimens and upon general workmanship being good meeting the tolerance requirements given elsewhere in the specification.

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#### **1.4.12 Primer Painting**

**1.4.12.1** Red oxide zinc chromate shall be used as primer. The requirements shall be as per IS: 2074 or the applicable industry standards.

**1.4.12.2** Unless specified otherwise in the schedule of items or elsewhere in this specification, surface preparation shall be done in accordance with IS: 1477 (Part - I). The surface shall be cleaned and degreased in accordance with one or more of the methods given in IS: 1477 (Part - I). The surface shall be de-rusted and de-scaled either mechanically or chemically by one or more of the methods given in IS: 1477. However flame cleaning and blast cleaning shall be resorted to wherever specifically mentioned in the schedule of items. While cleaning with power wire-brush, care shall be taken not to do it excessively, since mill scale easily gets burnished to a smooth even surface to which paints does not adhere, and this will be detrimental to the performance of paint. Power tools shall remove all accessible weld flux and splatter.

**1.4.12.3** Primer paint shall be applied by spray. Dry film thickness (DFT) of the two coats of red oxide zinc chromate shall be minimum 50 microns.

#### **1.4.12.4 Packing**

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 bolts, nuts, washers and small loose parts shall be packed separately in cases so as to prevent damage or distortion during transit.

#### **1.4.13 Stairs, Hand Railing and Ladders**

##### **1.4.13.1 General**

- a) Fabrication and erection of the stairs, railing and ladders shall be done as per the approved fabrication drawings.
- b) Preparation, submission checking and approval of the drawing shall be done in the same manner as specified for fabrication drawings elsewhere in this specification.

**1.4.13.2** All stairs and intermediate landings shall be constructed to size, dimensions and design, as indicated in the detailed drawings. Such stairway shall be fabricated as a complete

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unit which shall include struts, hangers, posts, cross bracing, cleats and accessories, as required for connection to structural steel framing and concrete.

**1.4.13.3** Stair treads shall be finished complete with punched and slotted carrier plates attached ready to bolt to stair stringers. Treads shall be provided with anti-skid nosing using Chequered plates and set flush with the stair treads.

**1.4.13.4** Pipe hand rails, as specified in detailed drawings, shall be assembled with flush type fittings and welded joints, ground and polished smooth. Railings shall be provided with all necessary fittings, posts, brackets, bolts, plates and similar accessories as shown on the detailed design drawings and as required for proper installation.

**1.4.13.5** Hand rails shall be of mild steel pipes of flush welded construction, ground smooth using 32mm nominal bore medium class pipes with top rail and middle rail, about 1.0 metre above platform / framing level and pipe posts spread not more than 1.5 metres apart.

**1.4.13.6** Smooth uniform curves and bends are to be provided at stair returns and also wherever specified / required. The open ends of all pipe posts shall be plugged and welded. A minimum radius of 3 times the pipe diameter shall be provided at all points of direction changes in the hand rails.

**1.4.13.7** Vertical ladders shall be as called for on the detailed design drawings. The ladders shall be provided with support arms formed with bent steel plate or clip angles. The ladders shall have loose neck supports, designed to form hand grabs and end brackets for fastening to abutting construction. Maximum deviation in the linear dimensions of railings, stairs and ladders, from the approved dimensions, shall not exceed 12 mm.

**1.4.13.8 Fabrication and Erection**

c) Railings shall be provided with all necessary fittings and accessories as required for proper installation.

**1.4.13.9 Acceptance Criteria**

Sampling, testing and quality assurance requirements are as given elsewhere in the document.

**1.4.14 Chequered Plate**

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**1.4.14.1** Minimum thickness of Chequered plate floorings, covers etc. shall be 6mm o/p. Chequered plates shall be fixed to supporting members by welding as shown / specified in relevant drawings or as directed by the Owner. The edges shall be made smooth and no burrs or jagged ends shall be left. While splicing, care should be taken so that there is continuity in pattern between the two portions. Care should also be taken to avoid distortion of the plate while welding of stiffening angle / vertical stiffening ribs. Surfaces shall be provided with primer paint.

**1.4.15 Electro-forged Steel Gratings**

**1.4.15.1 General Requirements**

- a) This covers the provision of gratings in but not limited to floorings, platforms, drain covers, trench covers, walkways, passages, structural treads with edge binding strips and anti skid nosing, etc.

**1.4.15.2 Material**

- a) Steel used in electro-forged gratings unit shall conform to grade 'A' of IS: 2062.

**1.4.15.3 Fabrication drawings**

- a) For gratings the Owner shall release the design drawing indicating the openings required and load intensity on the grating. Based on these drawing, the Contractor shall submit the grating design drawing for different spans and load intensities, along with the fabrication drawings. Thickness of gratings shall be kept as required by the design but shall be 40mm, unless specified otherwise.
- b) Preparation, submission, checking and approval of the drawing shall be done in the same manner as specified for fabrication drawings elsewhere in this document.

**1.4.15.4 Fabrication**

- a) All gratings shall be fabricated in a factory outside the project area.
- b) All grating units shall be rectangular in pattern and electro-forged. The size and the spacing of the bearing bars and cross bars shall be as detailed in fabrication drawings. The Contractor shall submit the grating design for different spans and loading intensities, along with fabrication drawings.

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- c) The grating unit shall be accurately fabricated and finished, free from warps, twists or any defects that would impair their strength, serviceability and appearance.
- d) The gratings shall be of reputed make and manufacturer, as approved by the Owner. Contractor shall provide all facilities and access to the Owner or his representative to carry out Inspection during all stages of manufacturing of gratings.
- e) Grating units shall be provided with all necessary clips, bolts, self drilling and tapping screws, nuts and lock washers required for proper assembly and rigid installation and fastening to abutting units / supporting structural steel framing members. Wherever required edge binding strip and anti-skid nosing shall be provided.

**1.4.15.5 Erection, Alignment and Installation of Gratings**

- a) Grating work shall include making cut outs and clear openings for all columns, pipes, ducts, conduits or any other installation penetrating through the grating work. Such cut outs and clearances shall be treated as specified in subsequent clauses.
- b) The gratings shall be notched, trimmed and neatly finished around flanges and webs of the columns, moment connections, cap plates and such other components of the steel structural encountered during the placement of the gratings. In all such cases, the trimming shall be done to follow the profile of the components encountered. After trimming the binding strip shall be provided on the grating to suit the profile so obtained.
- c) Opening in gratings for pipes or ducts that are 150mm (in size or diameter) or larger shall be provided with steel bar toe plates of not less than 5mm thickness and appropriate width, set flush with the bottom of the bearing bars.
- d) Penetrations in gratings that are more than 50mm but less than 150mm in size or diameter shall be welded with plates of size shown in the detailed drawing set flush with the bottom of the grating panel.
- e) Unless otherwise indicated on the drawing, grating units at all penetrations shall be made up in split section, accurately fitted and neatly finished to provide for proper assembly and erection at the job site.
- f) Grating shall preferably be installed in position by self drilling and tapping screws.

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#### **1.4.15.6 Painting**

All fabricated grating section and accessories shall be blast cleaned to near white metal surface (Sa 2 ½) followed by either of the following two:

- a) Two coats of red lead primer and two coats of black enamel finish paint.

All the provisions as mentioned for painting system with regard to preparation of surface, application of paint and acceptance criteria shall also be applicable.

- b) Hot dipped galvanization.

#### **1.4.15.7 Galvanization of Gratings**

- a) Wherever specified in the drawings, gratings shall be provided with galvanization. The weight of the zinc coating shall be at least 610 g. / Sq.m., unless noted otherwise.
- b) Purity of zinc to be used for galvanising shall be 99.5% as per IS: 209.
- c) After the shop work is complete, the structural material shall be punched with erection mark and be hot double dip galvanised. Before galvanising the steel section shall be thoroughly blast cleaned to near white metal surface (Sa 2 ½) or chemically cleaned.
- d) The galvanised surface shall consist of a continuous and uniformly thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be cleaned and smooth and shall be free from defects like discoloured patches, Bare spots, unevenness of coating, spelter which is loosely attached to the steel, blistered surface, flaking or peeling off etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.
- e) There shall be no flaking or loosening when structural squarely with a chisel faced hammer. The galvanised steel member shall withstand minimum four (4) numbers one minute dips in copper sulphate solution as per IS: 2633.
- f) When the steel section is removed from the galvanizing kettle, excess spelter shall be removed by “Bumping”. The processes known as “wiping” or “scrapping” shall not be used for this purpose.

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- g) Defects in certain members indicating presence of impurities in the galvanising bath in quantities larger than that permitted by the specifications or lack of quality control in any manner in the galvanising plant, shall render the entire production in the relevant shift liable to rejection.
- h) All gratings shall be treated with sodium dichromate or an approved equivalent solution after galvanising, so as to prevent white storage stains.
- i) If the galvanising of any member is damaged, the Owner shall be shown of the extent of damage, if so directed the galvanising may have to be redone in the similar manner as stated above at no extra cost to the Owner.

#### **1.4.16 Erection and alignment**

##### **1.4.16.1 Erection marks**

Erection marks in accordance with approved fabrication drawing shall be clearly painted on the fabricated steelwork. Each piece shall be marked in at least two places. Each piece shall also have its weight marked thereon.

**1.4.16.2** The center lines of all columns, elevations and beam bearings shall be marked on the sections to ensure proper alignment and assembly of the pieces at site.

##### **1.4.16.3 Erection Scheme**

- a) The Contractor shall submit for review of the work his erection scheme for the erection of all types of structural.
- b) The Contractor before commencement of fabrication work, to avoid any future modification shall check the erectability of the structural. The erection scheme shall indicate the approximate weight of the structural members, position of lifting hook, crane boom length, crane capacity at different boom length and at different boom inclination etc.
- c) The erection scheme shall also give details of the method of handling, transport, hoisting, including false work / staging, temporary bracing, guying, temporary strengthening etc. It will also give the complete details of the number and capacity of the various erection equipment that will be used such as cranes, winches, etc. along with disposition at the time of erection of column, trusses etc.

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- d) The Contractor shall examine the site conditions and transportation clearances before deciding whether columns, trusses, beams are to be transported in one piece or in more than one piece. All those steel members which are to be required to be erected in single piece but are transported in more than one piece shall be assembled, aligned bolted, welded, tested etc. on the proper assembly bed before erection at site.
- e) The erection of columns, trusses, trestles, portals, beams etc. shall be carried out in one single piece as far as practicable unless specified otherwise in the design drawing. Conveyor galleries and Pipe/Cable bridges shall generally be erected as box pieces i.e. the bottom chord and bracing, top chord and bracing, side vertical posts and bracing, end portals and roof-trusses shall be completely welded prior to erection and if required temporary strengthening during erection shall be made.
- f) The sheeting runners and roof sheeting purlins may be erected individually. When erection joints are provided in columns, their location shall generally be just above a floor level.
- g) The structural steel shall be erected frame-wise. Thereafter, the frames shall be progressively aligned and all erection welding completed. The secondary beams shall thereafter be erected, aligned and welded bay wise / floor-wise.

#### **1.4.16.4 Embedding in Concrete / Brickwork**

All embedments shall be placed true to level and location. It shall be ensured by the Contractor by provision of the temporary members and if required by welding of embedment lugs with nearby reinforcement. The embedments shall not be disturbed during concreting.

#### **1.4.16.5 Protection Against Damage In Transit**

- a) All steelwork shall be efficiently and sufficiently protected against damage in transit from fabrication yard to erection site from any cause whatsoever. All projecting plates and all ends of members at joints shall be stiffened.
- b) If the steel has been unduly bent in transit or during handling by the Contractor which cannot be rectified in the opinion of the weld, such steel shall be counted as

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wastage and the cost recovered from the Contractor at the time of reconciliation of the steel as per the -provisions of the contract.

#### **1.4.16.6 Stability of Structural Work**

The Contractor shall be responsible for the stability of the structural at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations. Guying and bracing shall be done in such a way that it does not interfere with the movement or working of other agencies working in the area. For the purpose of guying the Contractor shall not use other structural in the vicinity which are likely to be damaged by the guy.

#### **1.4.16.7 Temporary Structural Work**

The stipulations contained in the Indian standard safety code for erection of structural steel work, IS: 7205 shall be followed for ensuring safety of men and material. This shall include provision of temporary structural by the Contractor at his own cost for proper approach and working platforms during the erection of structural to the satisfaction of the Owner. The Contractor at his own cost shall provide any temporary strengthening needed. Temporary structural shall include access ladders, working platforms, railings, framework etc. All temporary structural shall be subsequently dismantled and removed.

#### **1.4.16.8 Setting Out**

Positioning and levelling of all steelwork, plumbing of stanchions and placing of every part of the structure with accuracy shall be in accordance with the detailed design drawings and to the satisfaction of the Engineer. For heavy columns, etc. the Contractor shall set proper screed bars to maintain proper level. No extra -payment shall be made for this.

No permanent field connections by riveting, bolting or shall be carried out until proper alignment and plumbing has been attained.

Column bases shall be set so that the column load is uniformly transmitted to the foundation. The Contractor shall carefully check the location and layout of anchor bolts embedded in foundations to ensure that the structural can be properly erected as per requirement. In some cases the bolts may be provided in the pipe sleeves / pockets in foundations for subsequent adjustment in final alignment of the foundation bolt. Before erection of columns on their foundations, the top surface of base concrete shall be

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thoroughly cleaned with wire brushes and by chipping to remove all laitance and loose material. The Contractor shall be responsible to provide all packing and shim plates whatsoever required for erection of the structural at his own cost.

#### **1.4.16.9 Alignment**

The Contractor shall be responsible for the correct alignment and leveling of all steelwork on site to ensure that the columns are in plumb and all the structural are erected conforming to the specified permissible erection tolerances. Welding works shall be done only after the approval of alignment of erected structural, by the weld.

#### **1.4.16.10 New Erection Marks**

Additional structures involving new erection marks may be required to be added at any stage of work.

All such new erection marks shall be detailed and included in marking schemes and fabrication carded out thereafter.

All such new erection marks shall be considered under item of original fabrication work. As a result of additional structures becoming necessary if the work is delayed beyond the time schedule stipulated, the Engineer shall give suitable extension of time provided he is satisfied about the reasonableness of the delay involved. However, no claim for extra payments or revision of rates due to delay shall be entertained.

#### **1.4.17 Painting System**

##### **1.4.17.1 Materials**

- a) Primer shall be Red Oxide Zinc Chromate primer (minimum 50 micron Dry Film Thickness - DFT) as per IS: 2074. (Minimum two (2) coats)
- b) Intermediate (Under) coat (minimum 50 micron DFT) shall be of synthetic enamel paint of approved shade and colour as per accepted standards
- c) Top / Finish coat (minimum 50 micron DFT) shall be of synthetic enamel paint of approved shade and colour with glossy finish as per accepted standards.
- d) However, areas/surfaces subjected to chemical attacks will be painted with epoxy paint/epoxy lining.

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- e) All paints including primer shall be of reputed brand / manufacturer and as approved by the Owner.

#### **1.4.17.2 Preparation of Surface**

- a) The surfaces shall be blast cleaned to near white metal surface (Sa 2 ½) i.e. 2nd quality (requiring at least 95% of the surface completely cleaned) as given in BS: 4232. For blast cleaning, dry method as approved shall be used.
- b) Approved type of abrasives shall only be used for blast cleaning of steel surfaces. To avoid contamination of the adjoining areas with abrasive, suitable enclosure shall be provided to carry out the blast cleaning operation. If required prior approval from the factory inspector / pollution control board etc. shall be obtained regarding the method of blast cleaning and abrasives used therein.
- c) Steel may be blast cleaned either before or after fabrication. Immediately after blast cleaning of the steel surfaces, primer coat shall be applied onto the surfaces.

#### **1.4.17.3 Application of paint**

- a) The Contractor shall submit the total painting scheme and works shall be started after the approval of the scheme, from the Owner.
- b) Painting works shall be carried out on structural as per the approved scheme. The total painting scheme to be submitted to the Owner shall include the following:
- i) Method of blast cleaning giving the details and sizing of various equipment required, abrasive used, enclosure provided to avoid contamination of the adjoining area, expected productivity on an eight (08) hour shift working etc.
- ii) Arrangement of airless spray with the equipment rating.
- iii) Drying time to be allowed before the application of subsequent coat.
- iv) Recommended paint for primer, intermediate (under) coat and finish / top coat with their brand name and designation, considering the requirements of applicable accepted standards.

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- v) Number of coat and the thickness of each coat to be applied to achieve the specified thickness of each coat i.e. primer, intermediate (under), and top / finish coats.
- vi) Environmental conditions i.e. ambient temperature and humidity at the time of application of the paint.
- vii) Quality control setup for painting i.e. checking of surface preparation, thickness of each coat, quality of applied paints vis-a-vis the approved sample etc.
- viii) Method of touch up painting for surfaces damaged during handling, transit, erection, welding, subsequent to painting, removal of the temporary supports etc.
- ix) Reference of relevant Indian / International standards for the testing and acceptance.
- c) Before application of Red Oxide Zinc Chromate primer, the steel surfaces shall be blast cleaned to near white metal surface (Sa 2 ½).
- d) Primer paint and intermediate (Under) coat shall be done by airless spray. However finish coat and final finish coat can be applied either by spray and or brush.
- e) All subsequent coats shall be applied only after acceptance of the previous applied coat. Inaccessible surfaces shall be primer painted before shop assembly.
- f) For final touch up painting of surfaces, which are damaged during handling, transit, erection, etc. surfaces shall be well prepared, by rubbing the entire damaged area using wire brush, emery paper etc. and shall be provided with same painting system as described elsewhere in this document. Touch up painting of areas welded subsequent to painting and areas exposed after removal of temporary supports shall also be carried out in same way.
- g) Rectification of the damaged painted surfaces on account of welding / handling etc. of each coat shall be done by touch up painting, before the application of next coat, using the same painting system as specified elsewhere in the document.

#### **1.4.17.4 Acceptance Criteria**

- a) All painted surfaces shall be uniform and pleasing in appearance.

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- b) Dry film thickness of each coat shall be checked and measured by using echo-meter. The thickness as measured shall not be less than the minimum thickness specified for the coat of paint under relevant clauses of the technical specification.
- c) Colour, texture shall match exactly with the approved sample.
- d) Sampling, testing and quality assurance requirements are given elsewhere in this technical specification.

#### **1.4.18 Foundation Bolts**

##### **1.4.18.1 General**

- a) Foundation bolt shall comprise of foundation bolts, nuts, lock nuts, anchor plates, stiffener plates, protective tape etc.
- b) All foundation bolts other than nut and lock nuts shall be site-fabricated.
- c) Every bolt shall be provided with nut and lock nuts. The nut and lock nuts shall be of reputed make and manufacture as approved by the Owner.

##### **1.4.18.2 Material**

- a) Foundation bolts shall generally conform to IS: 5624.
- b) Mild steel bars used for the fabrication of bolt assembly shall conform to grade '1' of IS: 432 and / or grade 'A' of IS: 2062.
- c) Hexagonal nuts and lock nuts shall conform to IS: 1363 and IS: 1364 upto M36 diameter and IS: 5624 for M42 to M150 diameter.

##### **1.4.18.3 Fabrication**

- a) The fabrication of bolt assemblies shall include threading, cutting, grinding, drilling, welding, etc. all complete.
- b) All bolts, bolt assemblies, etc. shall be fabricated to the correct dimensions and shapes as per requirement. The bolts shall have coarse pitch screw thread in the diameter range 8 to 64 mm and 6 mm pitch screw thread for diameter greater than 64 mm, as per IS: 4218.

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- c) For fabrication of any particular size of bolt, the diameter of the threaded portion of the bolt shall be considered as the diameter of the bolt.
- d) All nuts shall be of steel with well formed hexagonal heads, unless specified otherwise, forged from solid metal and shall be dipped in hot boiled linseed oil as soon as these are made. The nuts shall fit well on the bolts.
- e) Splicing in the foundation bolt can be done with full strength butt weld, which shall be further strengthened by provision of stiffening ribs for the full strength of the bolt. While splicing the foundation bolts, it shall be ensured that not more than 25% of the foundation bolts of each pedestal are spliced.

#### **1.4.18.4 Erection**

- a) During erection, necessary temporary members like template, bracing, supports, etc. to ensure proper positioning of the assemblies and alignment of the bolts and holding them firmly during concreting shall be provided by the Contractor at his own cost.
- b) All materials shall be erected in plumb and in level (unless otherwise specified) and at true locations as per requirement.
- c) Fabrication and erection shall be carried out as per IS: 800. Welding shall conform to IS: 816 and IS: 9595.

#### **1.4.19 Permanent bolts, Nuts and Washers**

##### **1.4.19.1 General Requirements**

- a) Permanent bolts shall be used for field connections only for those joints where so specified in the design document and fabrication drawings.
- b) All bolts, nuts, washers shall be of reputed make as approved by the Owner.

##### **1.4.19.2 Material**

- a) Permanent Mild Steel Bolts : The permanent mild steel bolts shall be of carbon steel of product Grade 'C' as per IS: 1363 (part - 2). The technical supply condition shall be as per IS: 1367 (part - I ). The threads shall be of class 8g as per metric screw

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threads of IS: 4218 (part - 6). The bolts shall be of diameter up to 39mm and shall conform to mechanical properties class 4.6 as per IS 1367 (part - 3).

- b) Permanent Mild Steel Nuts : The permanent mild steel nuts shall be of carbon steel of product grade C meeting the requirements of IS: 1363 (part - 2). The technical supply condition shall be as per IS: 1367 (part - 1). The Threads shall be of tolerance class 7H as per metric screw threads as per IS: 4218 (part - 6). The nuts up to diameter 16mm shall be of property class 5 and for diameters beyond 16mm and up to 39mm shall conform to property class either 4 or 5 as per the provisions of IS: 1367 (part - 6) or ISO 898 / 2.
- c) Permanent Mild Steel Washers : The permanent mild steel washers shall be of ordinary grade conforming to the requirements of IS: 5369 and IS: 2016. The washers shall be supplied in natural finish.
- d) Permanent High Strength Structural Bolts : The permanent high strength structural bolts shall be either of carbon steel with additives (e.g. Boron or Mn or Cr) quenched and tempered or carbon steel quenched and tempered of product grade C meeting the provisions of IS: 3757. The technical supply condition shall be as per IS: 1367 (part - 1). The threads shall conform to tolerance class 6g of IS: 4218 (part - 6). The bolts shall conform to mechanical properties class 8.8 as per is: 1367 (part - 3).
- e) High Strength Structural Nuts : High strength structural nuts shall be of product grade B meeting the requirements of IS: 6623. The technical supply condition shall be as per IS: 1367. The threads shall conform to tolerance class 6H as per metric screws threads of IS: 4218 (part - 6). The nuts shall conform to property class 8 of IS: 1367 (part - 6) / ISO 898 / 2 and all nuts shall be hardened and then tempered at temperature of at least 425°C.
- f) Washers for High Strength Structural Bolts and Nuts : The various types of washers for use with high strength structural bolts and nuts shall be of ordinary grade as per IS: 5369 and shall meet all the requirements of IS: 6649. The washer shall be made according to IS: 1570 (part - 2). The washer shall be thorough hardened and tempered. Washer shall be supplied in dull back heat-treated condition with residual coating of light oil.

### 1.4.19.3 Installation

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- a) Installation of the high strength bolts / high strength friction grip bolts shall be as per the requirements specified in IS: 4000.
- b) Mild steel bolts shall be installed and placed in position as per IS: 1363/ IS: 1367.
- c) Field Riveting

All rivets shall be heated and driven with pneumatic tools. Hand passing or "throwing" of rivets are desirable. Any other method of conveying hot rivets from the furnace to the driving point must be approved by the engineer. No cold rivets shall be driven. All other requirements of riveting including quality and acceptance criteria shall be in accordance with the relevant portions of the Specification for Fabrication of Structural Steelwork of the Project.

- d) Field Bolting

All relevant Portions in respect of bolted construction of the Specification for Fabrication of Structural Steelwork applicable to the Project 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 galvanizing.

All high tensile bolts shall be tightened to provide, when all fasteners in the joint are tight, the required minimum bolt tension by any of the following methods.

**i) 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 any 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

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nut rotation specified in Table-3 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-3**

<b>Bolts length not exceeding 8 times dia or 200 mm</b>	<b>Bolt length exceeding 8 times dia or 200 mm</b>	<b>Remarks</b>
1/2 turn	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.

Bolts may be installed without hardened washers when tightening is done by the turn -of-nut -method. However, normal washers shall be used.

Bolts tightened by the turn-of-nut method may have the outer face of the 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.

**ii) Torque Wrench Tightening**

When torque wrenches are used to provide the bolt tensions, the bolts shall be tightened to the torques specified in TABLE - 4 (See Note below the Table). 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 - 4**

Nominal Bolt Diameter (mm) (Kg.M) of IS: 1367	Torque to be applied for bolt class 8.8
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20	59.94
22	81.63
24	103.73

Note: The above torque values are approximate for providing tensions of 14.7 T for 20 mm dia. and 21.2 T for 24 mm dia. bolts under moderately lubricated condition. The torque wrench shall be calibrated at least once daily to find out the actual torque required to produce the above required tension in the bolt by placing it in a tension indicating device. These torques shall be applied for tightening the bolts on that day with the particular wrench.

In either of the above two methods, if required, for 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.

#### **1.4.20 Stainless Steel Hoppers**

##### **1.4.20.1 General Requirements**

- a) Stainless steel hopper can be of any shape like conical, hyperbolic, pyramid etc. and shall be used only when indicated in the design ( scope ) drawings of the Owner.

##### **1.4.20.2 Material**

- a) Stainless steel hopper shall conform to grade SS 415M of approved manufacturer.
- b) SS 415M shall have the following chemical composition.

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<b>Material</b>	<b>%</b>	<b>Remarks</b>
Carbon	0.03%	Max.
Silicon	1.60%	Max.
Manganese	0.80% to 1.50%	
Phosphorous	0.03%	Max.
Sulphur	0.03%	Max.
Chromium	10.80% to 12.50%	
Nickel	1.50%	Max.
Titanium	0.75%	Max.
Nitrogen	0.03%	Max.

The mechanical properties shall be as follows:

<b>Description</b>	<b>Value</b>	<b>Remarks</b>
Hardness rock well B scale	90	Max.
Tensile strength	450 Mpa	Min.
Yield strength	300 Mpa	Min.
Elongation	25%	Min.

- c) Contractor shall return to the Owner's store all unutilized (surplus) stainless steel plates and all waste and cut pieces generated. Non return of any part of the surplus / waste stainless steel pieces to the Owner's store will call for the penal recovery. The penal recovery for stainless steel shall be worked out in the same manner as mentioned in the special conditions of contract for maximum penal recovery for tile structural steel.

#### **1.4.20.3 Fabrication drawings of Hopper**

- a) The Contractor on the basis of the design / scope drawing furnished by Owner shall prepare the fabrication drawings. Fabrication drawings for the hopper shall include the cutting plan for each hopper plate. Cutting plans shall be based on the size of the stainless steel plates available at store.
- b) Most optimal solution for reducing the wastage of stainless steel plate shall be adopted. In order to reduce the wastage and ensure the maximum utilization of stainless steel plate, the cutting plan shall take into consideration the reverse curvature and place the various elements of hopper plate in opposite fashion to reduce the end wastage. Similarly the hopper plate element having different radii shall be placed one inside the other, to optimize the stainless steel plate use such

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optimization may also require adjustment in the size of the each element of hopper plate and also additional weld joints.

- c) The bill of material of hopper plate shall indicate the inner surface area of the hopper, weight of the hopper based on the inner surface area, weight of each of the cut plate for hopper fabrication, weight of cut and scrap pieces generated.
- d) In case the Contractor does the cutting of the stainless steel plates without approved cutting plan then all the wastage (i.e. the difference between the weight of stainless steel plate cuts and the actual finished weight considered for the measurement for payment) shall be subjected to the maximum penal recovery at the rate specified under relevant clause of the special conditions of contract. This clause will be applicable only when the material is free supply item to the Contractor by Owner.
- e) Preparation, submission, checking and approval of the drawing shall be done in the same manner as specified for fabrication drawings elsewhere in this document.

#### **1.4.20.4 Fabrication**

- a) Site Fabrication : The Fabrication, erection, alignment and welding shall be carried out as per the accepted practice and in accordance with relevant IS and international specification as well as stipulations contained herein. The Fabrication and erection works shall be done as per the approved fabrication drawings.
- b) Cutting : Cutting may be effected by shearing, or by using plasma. The cut edges of all plates shall be perfectly straight and uniform through out. Cutting shall be done as per the cutting plan shown in the fabrication drawing. All the edges shall be ground smooth before they are welded.
- c) Bending : The stainless steel plates shall be subjected to cold forming and bending in order to get the desired shape and profile.

#### **1.4.20.5 Welding**

- a) Welding shall be used for jointing of stainless steel plates.
- b) All weld joints (along the inclined plane) shall be staggered.

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- c) Stainless steel can be welded by any common welding process viz. MIG, metal arc or plasma using the covered compatible electrodes as per IS: 5206 or by inert gas arc welding as per IS: 2811.
- d) Shielding gas shall be Argon + Hydrogen mixture or Argon + Oxygen mixture. However, Argon + Oxygen mixture shall be preferred. Carbon dioxide mixture shall be avoided.

**1.4.20.6 Electrodes**

- a) 308L and 315L electrodes / fillers shall be used for the welding of stainless steel to stainless steel and stainless steel to mild steel respectively.
- b) The welding process and the type of the electrodes to be used for welding shall be as per welding procedure, as approved by the Owner.

**1.4.20.7 Welding sequence**

- a) The type of electrodes, welding sequence, preheat and Inter-pass temperature and post weld heat treatment shall be as approved by the Owner.

**1.4.20.8 Welder's Qualification**

- a) On the basis of the welding procedure, the Contractor shall conduct qualification test. All the welders to be employed for the job shall have to qualify the appropriate tests laid down in IS: 817 and IS: 1181 and ASME IX I AWS D1.1. All the necessary arrangements required for the testing and qualification of welders are to be provided by the Contractor.

**1.4.20.9 Acceptance criteria**

- a) Acceptance of the fabricated structural work shall depend upon the correct dimensions and alignment, absence of distortion in the structural, satisfactory results from the inspection and testing of the welded structural joints and the test specimens general workmanship being good and meeting the tolerance requirements as given IS: 7215.
- b) Sampling, testing and quality assurance requirements are given elsewhere in the specification

**1.4.21 Dismantling**

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#### **1.4.21.1 Dismantling of Steel Work**

- a) In case it is found that certain erection marks already erected at any elevation are to be dismantled for any reason whatsoever, this shall be done only on the written orders / permission of the Owner.
- b) Such dismantling shall be done carefully without damaging other structural and lowered to ground. Thereafter, it shall be carried to the field fabrication shop, if modifications are to be carried out or return to the project stores if the dismantled member is not to be re-erected at all. This operation may involve temporary dismantling, cutting, re-welding, supporting and restoring to correct position all temporarily dismantled members realigning of all other adjacent connected members, to their correct positions as well.

#### **1.4.22 Additions To, Alterations in and / or Modification**

##### **1.4.22.1 Modification of Erection Marks**

- a) In case, it is found that certain erection marks as already detailed and approved in fabrication drawings, require additions, alterations and modifications; this shall be done on the written orders of the Owner. Wherever a modification is ordered, the Contractor shall request the Owner in writing to examine the stage of completion of the erection mark. The weight of the erection mark (i.e. the calculated weight as per approved bill of materials) shall be recorded and termed as the unmodified weight of the erection mark.

##### **1.4.22.2 Additions To, Alterations In**

- a) If additions to, alterations in and / or modifications are intimated before completion and acceptance of fabrication of erection marks as per originally approved fabrication drawings, such changes shall not be classified as additions to, alterations in and / or modifications of erection marks and no payment shall be due to the Contractor for such additions, alterations and modification. If additions to, alterations in and / or modifications is ordered after completion and acceptance of fabrication and / or erection, payment shall be due to the Contractor for additions to, alterations in and/ or modifications.
- b) Normally the work of additions to, alterations in and / or modifications of erected erection marks shall be carried out in the erected position. Only in exceptional

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cases, where the Owner specifically approves that modification cannot be carried out in the erected position, the erection mark shall be dismantled.

- c) The work of additions to, alterations in and / or modifications may involve cutting of certain portions and parts, gouging of welds, cuttings, grinding, fabrication, welding, drilling holes specifically required for the work, straightening, raising to the required level, removal of bends, painting and touch up painting, transporting the cut and removed parts / items, pieces re-utilised out of cut and removed parts / items and new steel to be added. Wherever modification is involved it shall be done carefully without damaging other structural. In case of cutting from an erected member, the cut portion shall be safely lowered to the ground. Thereafter pieces not utilised out of such cut and removed parts shall be returned to the project stores if the Owner feels that these cannot be used elsewhere. Further the member from where the piece / item has been cut shall be ground smooth at the cut joint location. Modification may involve temporary dismantling, cutting, re-welding, supporting and restoring to the correct position of all temporarily dismantled members realigning of other adjacent connected members as well. Modifications to erection marks at erection site shall involve transporting the fabricated part / items (pieces re-utilized out of cut and removed parts / items and or new steel added) to erection site, raising to required level and welding in position. Modifications to erection marks in fabrication yard shall involve turning and handling of structural.
- d) Additions to, alterations in and / or modifications may be ordered either before erection or after erection and may have to be carried out either in erected position at erection site on the ground or in the fabrication shop. The scheme of dismantling and modification wherever required shall be got approved by the Owner before the work is taken up.

#### **1.4.23 Re-Erection Of Erection Marks After Additions, Alterations And Modifications**

- a) The items, where additions to, alterations in and / or modifications or change of erection mark have been ordered and such operations have necessarily to be carried out after dismantling, shall require re-erection.
- b) The work of re-erection includes carriage of modified erection marks from the field fabrication shop to erection site, lifting of same to the required position, aligning, and erecting in position, inclusive of erection bolts, tack welding and final welding and touch up painting etc., all complete to the satisfaction of the Owner. The work shall also involve the re-erection of members which had to be temporarily dismantled including temporary dismantling, cutting, re-welding, supporting and

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restoring to the correct position of all temporarily dismantled members, realignment of other adjacent connected members including gouging of welds, realigning, re-welding, etc. of such members.

#### **1.4.24 PTFE (Poly Tetra Fluoro Ethylene) Slide Bearings**

##### **1.4.24.1 General Requirements**

- a) The bearings shall consist of upper and lower units. The upper unit shall include a sole plate with mirror finish stainless steel facing bonded to the bottom surface of the sole plate. The lower unit shall consist of a relevant laminated elastomer pad surfaced with PTFE. A rigid confining medium substructure bonds the PTFE to the pad. When the upper and lower units are mated the stainless steel slides on the PTFE surface with an extremely low coefficient of friction. These bearings shall be designed by the manufacturer / Supplier of PTFE with the loads specified in the drawings as per the performance requirements. The bearing shall be of reputed make and manufacturer as approved by Owner, for required vertical loads, as per the construction drawing and for a maximum displacement of ( $\pm$ ) 50 mm.

##### **1.4.24.2 Material**

- a) PTFE bearing shall be sliding against highly polished stainless steel and the coefficient of friction between them shall be less than 0.06 at 55 kg / cm<sup>2</sup>. In order to prevent cold flow in the PTFE surface it shall be rigidly bonded by a special high temperature resistant adhesive to the stainless steel sub-strata. The stainless steel surface that slides against the PTFE is mirror polished. The stainless steel shall be bonded to the top plate by special high strength adhesive. The thickness of the stainless steel shall be between 1.0 to 1.5mm.
- b) The resilient bearing pad shall consist of multiple layers of lightweight fabric impregnated with a high quality elastomer compound vulcanised into slabs of uniform standard thickness as per the requirements. This shall withstand vertical (compressive) load not less than 500 Kg / sq. cm and shear loads up to 40 Kg / sq. cm.

##### **1.4.24.3 Installation**

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- a) The seating area for PTFE bearing shall be prepared accurately level and furnished with a thin layer of epoxy resin mortar. The bearing will be placed on this layer while it is still workable and the bearing is leveled. The bearing should not be displaced as the beam is lowered into position. When the mortar and adhesive are fully set and the beam is slightly above the top of the bearing, the upper surface of the bearing shall then be coated with sufficient thickness of epoxy resin mortar so that when the beam is lowered on to the temporary supports it comes into full contact with the mortar and some is squeezed out. The surplus mortar shall be trowelled off and after the mortar is fully set the temporary supports removed.

#### **1.4.25 Flexible Open Ended Bellow Strap**

##### **1.4.25.1 General Requirements**

- a) Pre-formed flexible open ended bellow strap of neoprene is to be provided between top of bunker and bottom of tripper floor or any other such place as directed by Owner, to avoid coal dust nuisance.

##### **1.4.25.2 Material**

- a) The pre-formed flexible open ended bellow strap shall be of reputed make and manufacturer, as approved by the Owner and shall consist of neoprene impregnated lightly woven tightly twisted light weight cotton canvas with aluminum striped edges.
- b) The life of the strap shall be guaranteed by the Contractor.
- c) The below strap shall be of minimum 200mm wide under un-stretched condition and shall be of minimum 2mm thick.

##### **1.4.25.3 Installation**

- a) The flexible open-ended strap shall be fixed in position with permanent bolts and it shall be ensured that sealing is total without any leakage.

#### **1.4.26 Coal Bin**

Shape of bins shall be circular, polygonal, square or rectangular in plan. Bottom hopper portion may have be conical-cum-hyperbolic or any other profile shape as shown in the

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drawing. Bin shall be termed as bunkers or silos according to their shape and plane of rupture of coal.

For general requirements, fabrication and construction details IS: 9178 (Part I, II) shall be followed as general guidance. The bins shall be fabricated and erected in segments.

The Coal bins shall be made of mild steel plates joined together with full strength butt weld and provided with stiffeners at regular interval. Stiffeners shall be provided on the external face and it may be welded with external face.

Bending of plates and rolled sections to the required shape for fabrication shall be done by plate bending machine or cold bending process Without resorting to heating, hammering, angle smithy and black smithy process

Poking hole (manual or pneumatic) and striking plate shall be provided to facilitate coal flow. Poking holes shall have circular MS pipe and cover cap as per requirement.

Trial assembly of coal bin/bunker including hopper shall be made at least for one bunker before commencing regular fabrication of the bunkers.

## **1.5.0 SAMPLING, TESTING, QUALITY ASSURANCE AND DELIVERY OF MATERIALS**

### **1.5.1.1 General**

- a) The Contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and/or International Standards and shall conduct such tests as called for by the Owner. Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent / accepted engineering practice to the directions of the Owner. Tests shall be done in the field and at a laboratory approved by the Owner and the Contractor shall submit to the Owner, the test results in triplicate within three days after completion of a test. The Owner may at his discretion, waive off some of the stipulations given for small and unimportant operations.
- b) Non Destructive Test (NDT) requirements for columns, crane girder frame, beam, truss, coal bins/bunkers etc., physical and chemical properties of material shall be as per relevant codes. Review of correlated Mill Test Certificates (MTC) or check testing in absence of MTC. Ultrasonic Test (UT) on plates above 40mm shall be as

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per ASTM A435. Welding Procedure & Welders Qualification Test shall be as per ASME Section IX / AWS D1.1

- c) The inspector shall have free access at all reasonable times to those parts of fabricators works which are concerned with the fabrication of the steel work and shall be afforded all reasonable facilities for satisfying himself that the fabrication is being undertaken as per provisions of this specification.
- d) The inspection shall be made at the place of fabrication prior to dispatch and shall be conducted so as not to interfere unnecessary with the operation of the work.
- e) Should any structure or part of a structure be found not to comply with any of the provisions of this standard , it shall be liable to rejection. Defects which may appear during fabrication shall be made good with the consent of and according to the procedure laid down by the Inspector / Owner
- f) All gauges, templates and instruments necessary to satisfy the Inspector shall be supplied by the fabricator. The Inspector, may, at his discretion check the test results obtained at the fabricators works by independent tests at the Government Test House or elsewhere and should the material so tested be found to be unsatisfactory, the costs of such tests shall be borne by the manufacturer.
- g) Material/work found unsuitable for acceptance, shall be removed and replaced by the Contractor. The work shall be redone as per specification requirements and to the satisfaction of the Owner.
- h) Radiography and ultrasonic testing of welds shall be carried out by Specialist agency only. In case, the Contractor does not have the required expertise, he shall engage Specialist agency for this purpose, after getting approval from the Owner.
- j) All steel supplied by, the Contractor shall conform, to the relevant Indian Standards. Except otherwise mentioned in the contract, only tested quality steel having mill test reports shall be used. In case unidentified steel materials are permitted to be used by the Engineer, random samples of materials will be taken from each unidentified lot of 50 M.T or less of any particular section for tests to conform to relevant Indian Standards. Cost of all tests shall be born by the contractor. All material shall be free from all imperfections, mill scales, slag intrusions, laminations, fittings, rusts etc. that may impair their strength, durability, and appearance.

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- k) The weld surface shall be cleaned with steel wire brush to remove spatter metal, slag etc. and 100% of welds shall be inspected visually for- size, length of weld and external defects. Weld gauges shall be used for checking weld sizes. The surface shall be clean with regular beads and free from slags, cracks, blowholes etc.

Non-destructive examination shall be carried out to determine soundness of weldments as follows:

- i) 10% at random on fillet-joints.

- ii) 100% on all butt-joints.

Should the ND tests indicate defects like improper root penetration, extensive blowholes, slag intrusion etc., such welds shall be back gauged, joints prepared again and re-welded. All defects shall be rectified by the Contractor at no extra cost to owner.

All electrodes shall be procured from approved reputed manufacturers with test certificates. The correct grade and size of electrode, which has not deteriorated in storage, shall be used. The inspection and testing of welding shall be performed in accordance with the provisions of the relevant Indian Standards or other equivalents. For every 50 tones of welded fabrication, the Engineer may ask for I (one) test-destructive or non-destructive including X -ray, ultrasonic test or similar, the cost of which shall be borne by the Contractor.

- l) Rivets, bolts, nuts and washers

All rivets, bolts, nuts, and washers shall be of approved make and shall confirm to the relevant Indian Standards. If desired by the Engineer, representative samples of these materials may have to be tested in an approved laboratory and in accordance with the procedures described in relevant Indian Standards. Cost of all such testing shall have to be borne by the Contractor. In addition to testing the rivets by hammer, 2% (two per cent) of the rivets done shall have to be cut off by chisels to ascertain the fit, quality of material and workmanship. The removal of the cut rivets and re-installing new rivets shall be done by the Contractor at his own cost.

- m) Shop painting

All paints and primers shall be of standard quality and procured from approved manufacturers and shall conform to the provisions of the relevant Indian Standards.

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n) Galvanizing

All galvanizing shall be uniform and of standard quality when tested in accordance with IS: 2633 - Method for testing uniformity of coating on Zinc Coated Articles and 15: 4759 - specification for Hot-Dip Zinc Coatings on Structural Steel & other allied products.

**1.5.2 Testing**

**1.5.2.1 General**

Loading tests shall be carried out on erected structures, if required by the Engineer, to check adequacy of fabrication and/or erection. Any structure or a part thereof found to be unsuitable for acceptance as a result of the test shall have to be dismantled and replaced with suitable member as per the Contract and no payment towards the cost of the dismantled portion and any connected work shall be made to the contractor. In course of dismantling, if any damage is done to any other parts of the structure or to any fixtures, the same shall be made good free of cost by the Contractor, to the satisfaction of the Engineer. The Cost of the tests specified hereinafter shall be borne by the Owner; but if the structure fails to pass the tests, the cost of the tests shall be recovered from the Contractor. Any extra claim due to loss of time, idle labour, etc. arising out of these testing operations shall not be entertained, however, only reasonable and appropriate time extensions will be allowed.

The structure or structural member under consideration shall be loaded with its actual dead load for as long a time as possible before testing and the tests shall be conducted as indicated in the following clauses. The method of testing and application of loading shall be as approved by the Engineer.

**1.5.2.2 Stiffness Test**

In this test, the structure or member shall be subjected, addition to its actual dead load, to a test load equal to 1.5 times the specified superimposed load, and this loading shall be maintained for 24 hours. The maximum deflection attained during the test shall be within the permissible limit. If, after removal of the test load, the member or structure does not show a recovery of at least 80 per cent of the maximum strain or deflection shown during 24 hours under load, the test shall be repeated. The structure or member shall be considered to have sufficient stiffness, provided that the recovery after this

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second test is not less than 90 per cent of the maximum increase in strain or deflection recorded during the second test.

### **1.5.2.3 Strength Test**

The structure or structural member under consideration shall be subjected, in addition to its actual dead load, to a test load equal to the sum of the dead load and twice the specified superimposed load, and this load shall be maintained for 24 hours.

In the case of wind load, a load corresponding to twice the specified wind load shall be applied and maintained for 24 hours, either with or without the vertical test load for more severe condition in the member under consideration or the structure as a whole. Complete tests under both conditions may be necessary to verify the strength of the structure. The structure shall be deemed to have adequate strength if, during the test, no part fails and if on the removal of the test load, the structure shows a recovery of at least 20 per cent of the maximum deflection or strain recorded during the 24 hours under load.

### **1.5.2.4 Structure of same design**

Where several structures are built to the same design and it is considered unnecessary to test all of them, one structure, as a prototype, shall be fully tested, as described in previous Sub-clauses, but in addition, during the first application of the test load, particular note shall be taken of the strain or deflection when the test load 1.5 times the specified superimposed load has been maintained for 24 hours. This information is required as a basis of comparison in any check test carried out on samples of the structure.

When a structure of the same type is selected for a check test, it shall be subjected, in addition to its actual dead load, to a superimposed test load, equal to 1.5 time the specified live load, in a manner and to an extent prescribed by the Engineer. This load shall be maintained for 24 hours, during which time, the maximum deflection shall be recorded. The check test shall be considered satisfactory, provided that the maximum strain or deflection recorded in the check test does not exceed by more than 20% of the maximum strain or deflection recorded at similar load in the test on the prototype.

### **1.5.2.5 Repair for subsequent test and use after strength tests**

An actual structure, which has passed the “Strength Test” and is subsequently to be erected for use, shall be considered satisfactory for use after it has been strengthened by replacing any distorted members and has subsequently satisfied the “Stiffness Test”.

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**1.5.2.6 Fillet Welds**

- a) Check for size and visual examination.
- b) Macrotech examination on production test coupons for main fillet welds with minimum one joint per built up beams, columns and crane girder etc.
- c) 25% weld length of tension member of crane girder shall be subjected to Dye Penetration Test (DPT)
- d) On all other fillet welds, DPT on 5% of weld length with minimum 300mm at each location shall be carried out.

**1.5.2.7 Butt Welds**

- a) 100% visual examination
- b) DPT on all butt welds after back gouging
- c) Mechanical testing of production test coupons with minimum one joint per built up beam, column and crane/gantry girder.
- d) 100% radiography test on butt welds of tension flange (bottom flange) of crane/gantry girder. All other butt welds shall be subjected to Radiography Test (RT) on 10% weld length of each welder. Wherever RT is not feasible, UT shall be carried out.
- e) Minimum 300mm length will be spot radio-graphed. When radiograph is not possible ultrasonic test will be carried out after grinding the surface with prior approval of Engineer.
- f) Full penetration welds (other than butt welds) shall be subjected to Ultrasonic Testing in following quantum:
  - i) 100% UT on web to flange joint of crane/gantry girder.
  - ii) 10% UT on other full penetration joints.

**1.5.2.8 Coal Bunker/Bins**

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- a) 10% DPT after back gouging.
- b) 5% spot radiography test on butt welds where access not available. UT shall be carried out with prior approval of Owner.
- c) In case of failure of any welds in SPOT RT/UT, the %age for retesting shall be doubled at that particular location. Acceptance criteria of Non Destructive Tests (NOT) on welds shall be as per AWS D1.1.

### **1.5.3 Tolerances**

#### **1.5.3.1 General**

All structure components/members shall be checked for dimensional tolerances during fabrication and erection as given below.

#### **a) Fabrication tolerances**

- i) Maximum permissible gap in built up members
- ii) Maximum permissible deviation in depth and/or width of girder at the joints
- iii) Maximum permissible out-of-square of flanges in built-up girders
- iv) Tolerances on length of beams and girders and their components
- v) Permissible deviation in column heights

All tolerances for above shall be as per IS: 7215

Tolerance on dimensions of individual rolled steel components shall be as specified in IS: 1852.

#### **b) Erection tolerances**

All tolerances shall be as per IS: 12843

- i) Permissible tolerances in erected steel columns

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- ii) Permissible tolerances in erected steel trusses
  - iii) Permissible tolerances in crane/gantry girder and rails
  - iv) Permissible tolerance limit for building with cranes shall be as listed below in the table.

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**Permissible Tolerance limits For Buildings Containing Cranes:**

Component	Description	Variation Allowed
I.	2.	3.
Main columns	<p>a) shifting of column axis at foundation level with respect to building line</p> <p>i) In longitudinal direction ii) In lateral direction mm</p> <p>b) Deviation of both major column axis from vertical between foundation and other member connection levels</p> <p>i) For a column up to and including 10M height ii) For a column greater than 10M but less than 40M height</p> <p>c) For adjacent pairs of columns across the width of the building prior to placing of truss</p> <p>d) For any individual column deviation of any bearing or resting level from levels shown on drawings.</p> <p>e) For adjacent pairs of columns either across the width of building or longitudinally level difference allowed between bearing or seating</p>	<p>i) <math>\pm 3.0</math> mm ii) <math>\pm 3.0</math></p> <p>i) <math>\pm 3.5</math>mm from true vertical ii) <math>\pm 3.5</math> mm from true vertical for any 10M length -measured between connection levels, but not more than <math>1 \pm 7</math> mm per 30m length.</p> <p><math>\pm 9.0</math> mm on true span.</p> <p><math>\pm 3.0</math> mm</p> <p>3.0mm</p>



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Component	Description	Variation Allowed
I.	2.	3.
Trusses	a) Deviation at centre of span of upper chord member from vertical plane running through centre of bottom chord  b) Lateral displacement of top chord at center of span from vertical plane running through center of supports	1/1500 of the span or not greater than 10mm whichever is the least.,  1/250 of depth of truss or 20 mm which ever is the least.
Crane Girders	a) Difference in levels of crane rail measured between adjacent columns.  b) Deviation to crane rail gauge  c) Relative shifting of ends of adjacent crane rail in plan and elevation after thermite welding.  d) Deviation of crane rail axis from centre line of web.	2.0mm  ±3.0mm  1mm  ±3.5 mm
Setting of Expansion gaps	At the time of setting of the expansion gaps, due regard shall be taken of the ambient temperature above or below 30° C. The coefficient of expansion or contraction shall be taken as 0.000012 per° C per unit length.	

**c) Requirement of pre-heating**

Thickness of thickest part at the point of welding electrodes	Welding using other than low hydrogen welding electrodes IS : 2062	Welding using low hydrogen welding electrodes or submerged arc welding IS:2062
Upto 20 mm	None	None

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(including)

Over 20 mm to 40 mm 66°C 20°C  
(including)

Over 20 mm to 63 mm Not allowed 00°C  
(including)

Over 63 mm Not allowed 110°C

The tolerances for Embedded part in concrete shall be as specified in technical specification for concrete works.

#### 1.5.4 **Quality Assurance Program**

The Contractor shall submit and finalise a detailed Field Quality Assurance Programme within 30 days from the date of award, before commencement of the work, according to the requirements of the specification. This shall include setting up of a testing laboratory, arrangement of testing apparatus/ equipment, deployment of qualified/ experienced manpower, preparation of format for record, field quality plan, etc. On finalised field quality plan, the Owner shall identify, customer hold points beyond which work shall not proceed without written approval from the Owner.

The contractor shall establish and maintain quality control procedures for different items of work and materials as may be directed by the Engineer to assure compliance with the provisions of the Contract and shall submit the records of the same to the Engineer. The quality control operation shall include but not be limited to the following items of work:

- i) Erection: Lines, levels, grades, plumbs, joint characteristics including tightness of bolts.
- ii) Grouting: Cleaning and roughness of foundation, quality of materials used for grouting, admixtures, consistency, and strength of grout.
- iii) Painting: Preparation of surface for painting, quality of primers and paints, thinners, application and uniformity of coats.

Materials or workmanship not in reasonable conformance with the provisions of this Specification may be rejected at any time during the progress of the work.

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- a) The quality control procedure shall cover but not be limited to the following items of work: -
- i) Steel : Quality, manufacturer's test certificates, test reports of representative samples of materials from unidentified stocks if permitted to be used.
  - ii) Bolts, Nuts & Washers : Manufacture's certificate, dimension checks, material testing.
  - iii) Electrodes : Manufacturer's certificate, thickness and quality of flux coating.
  - iv) Welders : Qualifying Tests
  - v) Welding Sets : Performance Tests
  - vi) Welds : Inspection, X-ray, Ultrasonic tests
  - vii) Paints : Manufacturer's Test certificate, physical inspection reports
  - viii) PTFE bearings, Neoprene Bellow Strap : Manufacturer's Test certificate, physical inspection reports
- b) The dimensions, forms, weights and tolerances of all rolled shapes , bolts, nuts, studs, washers etc. and other members used in the fabrication of any structure shall, wherever applicable, conform to the requirements of the latest relevant Indian Standards, wherever they exist or in the absence of Indian Standards to other equivalent standards.

### 1.5.5 Acceptance Criteria

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 Engineer considers the defects rectifiable. The Engineer may, at his discretion, check some of the tests at an appropriate laboratory at the contractor's cost.

When all tests to be performed in the Contractor's shop under the terms of this contract have been successfully carried out, the steelwork will be accepted forthwith and the

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Engineer will issue acceptance certificate, upon receipt of which, the items will be shop painted, packed and dispatched. No item 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 to accept the work, should it, on further tests before or after erection, be found not in compliance with the Contract.

Structures and members have passed the tests and conform to all requirements specified in the foregoing clauses and other applicable provisions of this specification and are within the limits of tolerances specified in relevant clauses and/or otherwise approved by the Owner shall be treated as approved and accepted for the purpose of fulfillment of the provisions of this contract.

### **1.5.6 Delivery of Materials**

#### **1.5.6.1 General**

The Contractor will deliver the fabricated structural steel materials to site with all necessary field connection materials in such sequence as will permit the most efficient and economical performance of the erection work. The Owner may prescribe or control the sequence of delivery of materials, at his own discretion.

The Contractor shall take delivery of fabricated structural steel and necessary connection materials from railhead/trucks as may be necessary and as directed by the Engineer. He shall check, unload; transport the materials to his stores for proper storing at his own cost. The Contractor shall submit claims to insurance or other authorities and pursue the same in case of loss or damage during transit and handling and all loss thereof shall be borne by him.

The Contractor shall also take all precautions against damage of the materials in his custody after taking delivery and till the same are erected in place and accepted. The Contractor shall salvage, collect, and deliver all the packing materials to the Owner free of charge.

#### **1.5.6.2 Marking**

Each separate piece of fabricated steelwork shall be distinctly marked on all surfaces before delivery in accordance with the markings shown on approved erection drawings and shall bear such other marks as- will further facilitate identification and erection.

#### **1.5.6.3 Shipping**

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Shipping shall be strictly in accordance with the sequence stipulated in the agreed Programme. Contractor shall dispatch the materials to the work site securely protecting and packing the materials to avoid loss or damage during transport by rail, road or water. All parts shall be adequately braced to prevent damage in transit.

Each bundle, bale or package delivered under this contract shall be marked on as many sides as possible and such distinct marking (all previous irrelevant markings being carefully obliterated) shall show the following:

- Name and address of the consignee
- Name and address of the consignor
- Gross weight of the package in tonnes and its dimensions
- Identification marks and/or number of the package
- Custom registration number, if required

All markings shall be carried out with such materials as would ensure quick drying and indelibility.

Each component or part or piece of material when shipped, shall be indelibly marked and/or tagged with reference to assembly drawings and corresponding piece numbers.

Each packing case shall contain in duplicate in English a packing list pasted on to the inside of the cover in a water-proof envelope, quoting especially

- Name of the Contractor
- Number and date of the Contract
- Name of the office placing the contract
- Nomenclature of stores
- A schedule of parts or pieces, giving the parts or piece number with reference to assembly drawings and the quantity of each.

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The shipping dimensions of each packing shall not exceed the maximum dimensions permissible for transport over the Indian Railways/Roads.

After delivery of the materials at site, all packing materials shall automatically become the property of the Owner.

Notwithstanding anything stated herein before, any loss or damage resulting from inadequate packing shall be made good by the Contractor at no additional cost to the Owner. When facilities exist, all shipments shall be covered by approved Insurance Policy for transit at the cost of the Contractor.

The contractor shall ship the complete materials or part on board a vessel belonging to an agency approved by the owner or on rail and/or road transport as directed. The Contractor- shall take all reasonable steps to ensure correct appraisal of freight rates, weights and volumes and in no case will the Owner be liable to pay any warehouse, wharf age, demurrage and other charges.

If, however, the Owner has to make payment of any of the above-mentioned charges, the amount paid will be deducted from the bills of the Contractor.

Necessary advice regarding the shipment with relevant details shall reach the Engineer at least a week in advance.

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