# 4X270 MW BHADRADRI TPS

# TSGENCO

# VOLUME – II B

## CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

SPECIFICATION NO. PE-TS-411-620-C001

## SECTION – C1

## *SPECIFIC TECHNICAL REQUIRMENTS*

Maharatna Company

BHARAT HEAVY ELECTRICALS LIMITED
PROJECT ENGINEERING MANAGEMENT
NOIDA 201301

# SECTION – C1

NOTE: In case of any conflict between section –C1 and section-C2, Section C1 of specification prevails.

## 220 M HIGH TWIN FLUE RCC CHIMNEY
## 4x270 MW MANUGURU TPS

### 1.1 General Parameters of the Chimney

| | | | |
|---|---|---|---|
| 1 | No. of Chimneys | : | 2 |
| 2 | Total height of the chimney above finished grade level | : | 275 M |
| 3 | No of flues in each chimney | : | 2 |
| 3 | No of boilers | : | 4 |

### GENERAL DESCRIPTION:

1.2 Chimney for the two unit shall be 275m high. The lower concrete shell windshield upto +269m level encloses flue made up of mild steel. The upper concrete minishell windshields enclose flue from 269 level to 275m level. The upper flue from 269 level to 275m level shall be made up of RCC lined by Acid and Heat resistant bricks of class-II bricks. Flue shall be supported on steel platforms at an interval of 45 m approx. Mild steel shall be used for the flue throughout the chimney height.

1.3 External platforms with minimum clear platform width of 1.0m, shall be provided at an interval of approximately 45 m. These external platforms shall be spaced approximately equally between the hood platform and ground level and shall also be located at levels of internal platforms for easy access.

1.4 All internal platforms, supporting flue, shall be supported on steel beams. The steel beams shall be supported on the concrete shell windshield. Internal structural steel staircase, connecting all platforms, shall be provided. This staircase shall be supported on structural steel brackets taken out from shell. Access doors shall be provided at grade level and external platform levels for entry into the shell at finished grade level and for entry to external platforms. Inspection / maintenance doors shall also be provided in the flue at appropriate level near internal platform level.

### 2.0 BASIS FOR DESIGN

2.1 The concrete shell windshields shall be designed in accordance with IS : 4998 (Part-1 ), 1975 & 1992, " Criteria for Design of Reinforced Concrete Chimneys ". Reference may also be made to ACI : 307-1979, " Specification for Design and Construction of Reinforced Concrete Chimneys ", if some aspect is not covered in the Indian Code.

2.2 In addition to the codes specified in clause 2.1 above, the latest editions of the following codes, standards and documents shall also be followed in the design and construction of the RC chimney system.

a) IS:456-2000 - Code of Practice for Plain & Reinforced Concrete
b) IS:875 (Part 3 -1987) - Code of Practice for Wind Load
c) IS: 1893-2002(Part I) - Criteria for Earthquake Resistant Design of Structures

d) IS: 432 (Part-I) - Mild Steel and Medium Steel Bars.
e) IS: 1786 - Cold Twisted Steel Bars for Concrete Reinforcement
f) IS: 800 - Use of Structural Steel in General Building Construction
g) CICIND - International Committee on Industrial Chimneys
h) Manohar S.N., " Tall Chimneys – Design and Construction ", Tata McGraw Hill Publication.
i) Pinfold M.G., " Reinforced Concrete Chimneys and Towers ", View Point Publication

2.3 Concrete shell windshields shall be of concrete grade min. M-30. foundation shall be of M-25 grade concrete . Reinforcement shall be as per latest codes.

## 3.0 LOADS AND THEIR COMBINATIONS

### 3.1 Dead Loads

All permanent loads due to the weight of concrete shell windshields, hood platform, external platforms, internal platforms and linings supported on them, ladders, flue ducts, staircases, elevators and other accessories shall be considered.

### 3.2 Imposed Loads

Imposed load on external platforms shall be taken as 500 kg/$m^2$

### 3.3 Wind Load

**3.3.1** The wind loading shall conform to IS:875 (Part -3) : 1987 for a basic wind speed of 44 m/sec..

The final design will be checked and verified by wind tunnel tests at any reputed institute. Dynamic interference effects due to additional chimney(s) and other structures located in area of future expansion shall be determined with wind tunnel tests of chimney model. If needed, modifications shall be made in the design of concrete shell windshields and foundation.

Design of discrete galvanised steel strakes shall be as per IS 4998 (Part-1). However, strakes shall be provided if found necessary by wind tunnel studies.

### 3.4 Seismic Load

The site falls in Zone-III as identified in the map in IS: 1893. Analysis and design of structures to resist the seismic forces will be established in accordance with the recommendations of IS: 1893.

### 3.5 Thermal Effect

Due to the effect of temperature gradient, vertical and circumferential stresses are developed. Thermal stresses induced in the concrete shell shall not exceed values given in IS:4998.

The temperature gradient $\triangle T$ across the shell thickness shall be calculated as per IS:4998 (Part -I) -1975. Temperature stresses will be calculated according to the procedures given in ACI -307 and IS:4998 (Part 1) -1975.

Vertical and circumferential reinforcement shall be provided for temperature stresses.

### 3.6 Local Loads

The effect of following local loads shall be considered :

a) Local moment due to platforms.
c) Local moment due to occurrence of ovalling.
d) Local moment produced by thermal gradient.

### 3.7 Load Combinations

**Various load combinations for calculation of stresses shall be as under :**

a) Dead loads
b) Dead load + Wind load.
c) Dead load + Seismic forces.
d) Dead load + Temperature effect.
e) Dead load + Wind load + Temperature effect.
f) Dead load + Earthquake force + Temperature effect.
g) Circumferential stresses due to temperature effect.
h) Circumferential tensile stresses due to wind inducing ring moment.
i) Circumferential compressive stress due to wind induced ring moment combined with temperature.

In load combinations (a) to (f) above, dead load considered shall be with & without the weight of flues. Whichever condition is more critical, shall be adopted for design. Across wind loads shall be combined with coexisting wind loads. The combined design moment at any section shall be taken as the SRSS of the moments due to across wind loads and coexisting along wind loads. In addition to load condition mentioned above, the chimney will be checked for local loads as per Cl 3.6.

## 4.0 PERMISSIBLE STRESSES FOR CHIMNEY SHELL

The stresses in concrete shall not exceed the limits given in clause 7.0 of IS: 4998 (Part I) – 1975 for various combinations of loads excepting the case of dead load + wind load.

## 5.0 ANALYSIS

### 5.1 Free Vibration Characteristics of Concrete Shell Windshield

Natural frequencies and mode shapes shall be calculated. For this purpose the chimney shaft shall be idealized as a vertical cantilever with lumped masses at different nodes. Nodes shall be provided at each platform level. Natural frequencies and mode shapes shall be computed for two cases of dead loads ( with & without flues + platforms ).

Lower values of dynamic modulus of elasticity of concrete, as recommended in IS:4998 (Part -1) 1992 shall be used for calculating the natural frequencies of the chimney.

### 5.2 Wind Analysis

### 5.2.1 Along Wind Analysis

The basic wind speed and other details (to be furnished later as per customer details).

The gust factor shall be calculated using the method given in IS:4998 (Part -1) -1992. Drag co-efficient $C_d$ shall be taken as 0.8 for the concrete shell windshield.

Along wind response of chimney shall be calculated both by the gust factor method in A-5.1 and the simplified method in A-4.1 of IS: 4998 part-I, 1992. For design, higher of the along wind loads shall be used.

**5.2.2 Across Wind Analysis**

Across wind response of the chimney will be evaluated as per the method given in Section A-4 as well as A-5 of IS:4998 (Part I) –1992. Lift co-efficient $C_l = 0.16$ and $S = 0.2$ shall be considered. Higher of the two moments shall be considered for design.

**5.2.3 Ring Moments Due to Wind**

The circumferential ring moment due to wind shall be calculated in accordance with clause 5.4 of IS:4998 (Part -1) –1992. The wind induced stresses in concrete and steel shall be calculated in accordance with cl no. D-2.2.7, D-2.2.8 and D-2.2.9 of IS 4998 (part I)-1975.

**5.3 Seismic Analysis**

to be furnished later as per customer details.

**5.4 Stability Check**

For a lined chimney, factor of safety against overturning is not less than 1.5, when the weights of lining, insulation and accessories are not considered and shall not be less than 2, when weights of lining, insulation and accessories are considered.

**6.0 COMPONENT DESIGN CRITERIA**

*6.1 CONCRETE SHELL WINDSHIELD*

Design conditions for the concrete shell windshield shall be as follows :

(1) The concrete shell shall be designed for natural phenomena, loads and load combinations. Working stress method shall be used for design. Modular ratio shall be calculated as per Annexure–B of IS 456 – 2000. Only one grade of concrete shall be used throughout the height of the concrete shell.

(2) Maximum deflection at the top of the chimney for both static and dynamic cases shall not be more than H/500 where H is the total height of the concrete shell windshield above top of the pile cap.

(3) The static modulus of elasticity of concrete shall be taken as $5000\sqrt{f_{ck}}$ for instantaneous loadings, where $f_{ck}$ is the characteristic compressive strength of concrete as per clause 6.2.3 of IS : 456 – 2000.The dynamic modulus of elasticity of concrete for various concrete grades will be taken as lower values in the range of values specified in Is:4998(Part-I)-1992.

(4) Minimum thickness of concrete shell upto 214m height shall not be less than 250 mm. Minimum thickness of concrete minishell between 214m & 220m shall not be less than 150 mm. Minimum clear cover to reinforcement shall be 50 mm.

(5) Reinforcement in the concrete shell shall be provided as per IS : 4998 (part – I) – 1975. However, the maximum spacing of reinforcement shall not be more than 300 mm both ways in the shell and 300mm for the foundation raft.

Minimum Reinforcement for shell shall be as per the provisions of relevant IS code.

The total number of vertical bars in the concrete shell shall be continued till such height where alternate bars can be discontinued. However, reduction of bar diameter along the height is permissible. Vertical bars shall be uniformly spaced at any section of the shell. One third of the vertical bars can only be lapped at one section.

(6) Openings shall be provided in the concrete shell for ductworks, access doors, ash channel, ventilation system etc. The maximum width of opening shall be limited to an angle of not more than 30° subtended at the centre of the concrete shell. The total plan area of the openings at a particular section shall not be more than 15% of the plan area of concrete shell at that location. Opening size for the purpose of stress calculations shall be taken as 1.1 times the actual width of the opening. Extra reinforcement around the opening shall satisfy the requirements given in the following documents and the highest shall be provided :

a) IS 4998 (Part I)

b) ACI 307

c) " Reinforced Concrete Chimney and Tower " by M.G. Pinfold : Value of K1, given in page no. 186 shall be taken as 0.11.

(7) Embedment shall be provided in the concrete shell to support the stair case.

(8) Expansion anchors shall be used to attach conduits, earthing lightning protection conductor, lighting fixtures and other lightweight appurtenances.

(9) Suitable cutouts ( openings ) shall be provided in the concrete shell for intake of air for ventilation. Similar cutouts ( openings ) shall be provided near the hood platform.

(10) Concrete shell surface shall have smooth surface.

## 6.2 FLUE

The function of chimney flue is to exhaust the combustion gases from the chimney. The flue are designed to protect the concrete shell from high temperature, pressure, corrosion and abrasion properties of the flue gases.

The flue shall be made up of mild steel through out the height of chimney . Only at top portion of chimney (apporx. 6m) the flue shall be made up of RCC lined by Acid & Heat resistant bricks.

The design conditions for the steel flue shall be as follows:

1. The steel flue shall be designed as per specifications of Design & Construction of steel Chimney liner, Task Committee on Steel chimney liner, Fossil Power Committee, Power Division published by ACE 1975.
2. The Structural steel liners and the inlet transition ducts including stiffners and liner bearing shall be fabricated using materials conforming to the requirements of IS:800 and IS:2062 (grade A for plates and sections upto 20mm thick and grade-B killed & normalized for plates and sections thicker than 20 mm ) and shall be from steel having an ultimate tensile strength of not less than 410 N/sqmm. Minimum thickness of 10 mm (inclusive of corrosion allowance) shall be provided for liner plates.

3. 50 mm thick insulation ( in two 25mm thick layers ) of reisin bonded rock wool shall be provided on the outer surface of the flue. Minimum density of insulating material shall be 100kg/cum and thermal conductivity shall be not more than 0.044 Kcal/M/hour/deg. centigrade at the mean temperature of 100 deg. centigrade.
4. Minimum clearance between the flue and concrete shell shall not be less than 0.9 m.
5. Provisions shall be made for flue to expand both circumferentially and vertically without producing stress in the concrete shell.

**6.3 INTERNAL PLATFORMS**

6.3.1 Steel flue shall be supported by structural steel internal platforms. Internal platforms shall be located at approximately 45.0 m intervals along the height of the chimney. The platforms are made up of structural steel girders. The girders are supported on mild steel bearing assembly in pockets within the shell and corbels.

6.3.2 Internal platforms shall be designed for the following loads :

1) Dead loads of the component.
2) Dead loads of the flues
3) Live loads on the platforms during operation and maintenance ( 500 Kg/$m^2$ min. )
4) Construction loads and live load during construction

6.3.2 Chequered plate shall be provided for internal platforms .

**6.4 STEEL GIRDERS**

6.4.1 Deflection of girders shall not exceed span / 325.

6.4.2 The minimum thickness of web for girders carrying the flue load shall be kept as 12mm. The two girders carrying the load of steel flues shall rest on mild steel bearing assembly supported on the concrete shell in pockets or through and through openings in the concrete shell. Through and through openings beyond the mild steel bearing assembly shall be closed later on by bending back reinforcement bars at the external face of the concrete shell and concreting with same grade of concrete as that of the concrete shell. Working stress method shall be adopted for the design.

6.4.3 The steel framing system for platforms shall be painted with synthetic enamel paint over appropriate primer.

**6.5 HOOD & PLATFORMS**

RCC hood platform at 214m level are to be built with the concrete shell. 20 mm thick Acid & heat resistant tiles shall be provided at roof platform. Proper drainage arrangement shall be provided for hood & platform.

**6.6.0 EXTERNAL PLATFORMS**

6.6.1 External platforms are to be provided for aviation obstruction lights to meet the requirements of IS : 4998 ( latest edition ), ICAO regulations & instructions issued by Director General of Civil Aviation.

6.6.2 Minimum clear width of platforms shall be 1000 mm. A live load of 500 kg/$m^2$ shall be considered for their design.

6.6.3 20mm thick acid resistant tiles conforming to IS : 4457 ( latest edition ) in acid resisting mortar shall be laid over waterproofing for hood platform and all external platforms. Average thickness of mortar bed shall be 10 mm and it shall slope outwards.

6.6.4 Hand railing shall be provided all around the external platforms and hood platform using minimum 32 mm galvanised steel pipes medium grade of IS 1239 / IS 1161. Spacing of railing posts shall not be more than 1500 mm centre to centre with a minimum height of 1000 mm.

32mm dia GI drainage spouts shall be provided to carry rain water from hood platform to discharge point at ground level. 150 mm dia galvanised steel RWDC pipe shall be provided to carry rain water from hood platform to discharge point at ground level. The number of down take pipes shall be decided as per design .

## 6.7.0 FOUNDATION

A circular foundation, preferably annular, shall be provided. The foundation shall have uniform thickness. Minimum thickness of raft shall neither be less than 0.09 times the diameter of raft nor 0.4 times the overhang of the raft from the face of the concrete shell. Minimum reinforcement shall not be less than 0.12% in each direction and each face of foundation. Wind and earthquake loads shall be treated as normal load without increase in allowable stress in soil, concrete and steel. No tension will be allowed under the raft during earthquake and wind loads. Working stress method shall be adopted for design of foundation. The top of foundation shall be kept at minimum 1.0m below the surrounding grade level of chimney area.

All recommendations for foundation design given in soil report are to be considered.

## 6.8.0 ROLLING SHUTTER DOOR

6.8.1 A rolling shutter, electrically and manually operated, of size 5.5 m X 7.0 m shall be installed at the base of the chimney shell so that a truck could go inside the chimney if required. The door shall be installed complete with guides, hood, hardware, weather baffles, combination end locks and wind locks, mechanisms and accessories as required for proper operation and weather protection. Details of rolling shutter shall conform to IS : 6248 ( latest edition ) " Metal Rolling Shutters & Rolling Girds " and to the technical specifications. The door shall be painted with synthetic enamel paint with appropriate primer.

## 6.9 PERSONNEL ACCESS DOORS

6.9.1 Steel personnel access doors shall be hollow metal doors of size 1200 mm x 2100 mm. One personnel access door shall be provided at grade level for access inside area of the chimney. Personnel access doors shall also be provided in chimney shell at external platform levels so that civil aviation lights mounted on these platforms could be approached for maintenance and replacement purposes. All these doors shall swing to bear against the seals. Door surfaces, frames and other hardware facing the interior of the chimney

shall be painted with primer and finished painted with two coats of acid and heat resistant paint. Other surfaces shall be painted with primer and finish painted with two coats of aluminium paint to give an even shade.

## 6.10 INSPECTION & MAINTENANCE HATCH

6.10.1 Steel leak proof hollow M.S. doors of size 800 mm $\phi$ shall be provided diametrically opposite in each steel flue at all those levels where external platforms are provided. The hollow space in the door shall be filled with insulating material so that the temperature of outside surface of door is not more than 50 $^0$C. Additional insulation on exterior face of the doors shall be provided.

6.10.2 Proper sealing arrangement using woven asbestos gaskets shall be provided in the doors, so that there is no leakage of the flue gas from mild steel flues into the annular space between liner and shell through these doors.

## 6.11 ACCESS HATCHES

6.11.1 A mild steel hatch frame with door shall be provided for access to the hood platform of the chimney.

6.11.2 Hatch frames & doors shall be painted with two coat of primer and finish painted with two coats of acid and heat resistant paint on both sides.

6.11.3 The hatch doors shall be flat and shall be operated upwards. They shall be provided with locking arrangements from under side for the hatch door at hood platform.

## 6.12 MILD STEEL BEARING ASSEMBLY

Mild steel bearing assembly conforming to relevant codes shall be provided below steel girders at support points in concrete shell pockets to accommodate thermal movements and to provide a suitable distribution of load.

## 6.13 FLUE OPENINGS AND DUCT WORK

The concrete shell at flue duct entry shall be adequately protected against high temperature by castable refractory lining. The gap between the shell and duct shall be properly sealed off by asbestos or any other suitable seal.

Openings in the concrete shell for flue duct entry shall be adequately reinforced to withstand design loads.

## 6.14 CHIMNEY PAINTING

6.14.1 The inside surface of the chimney shell above roof, horizontal surface of the shell at top, underside of roof slab, inside and outside surfaces of mini-shell, top exposed surface of external platforms etc shall be painted with acid & heat resistant black bituminous paint conforming to IS:158. Total dry film shall not be less than 150 micron.

6.14.2 The entire outside surface of concrete shell shall be painted with alternate bands of signal red and white colour, out of which top 50 m ( approx. ) shall be painted with acid and heat resistant polyurethane paint and rest of the outside surface shall be painted with cement paint in alternate bands of red and white colour.

## 6.15 EXPANSION COMPENSATOR

A flexible textured cloth type including glass felt bolster shall be provided at every location, wherever provision of vertical expansion is kept for liner.

# TELANGANA STATE POWER GENERATION CORPORATION LIMITED
# [TSGENCO]

## BHADRADRI THERMAL POWER STATION
## [4 x 270 MW]

# VOLUME – II B
## TECHNICAL SPECIFICATIONS FOR RCC CHIMNEY

## SPECIFICATION NO. PE-TS-411-620-C001

## SECTION - C *2*
## *SPECIFIC TECHNICAL REQUIREMENTS*


**Bharat Heavy Electricals Limited**
**Project Engineering Management**
**PPEI Building, Power Sector,**
**Plot No. 25, Sector 16A,**
**Noida (U.P.)-201301**

# VOLUME : VII-A

# GENERAL SPECIFICATION AND DESIGN CRITERIA FOR CIVIL AND STRUCTURAL WORKS

**NOTE: In case of any conflict between section ï C1 and section-C2, Section C1 of specification prevails.**

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**VOLUME : VII-A** **GENERAL SPECIFICATION AND DESIGN CRITERIA FOR CIVIL AND STRUCTURAL WORKS [Contd…]**

3.00.00 **CODES AND STANDARDS**

Following is a general listing of Codes and Standards to be used in the design of the Plant. Specific a pplicable codes and st andards will be identified in System Design Descriptions/Tech nical Specif ications a s appropriate. The latest editions/revision of following codes and standards alon g with addendums/amendments, if any, shall be followed :

| | |
|---|---|

3.01.00 **General**

a) Internationally accepted design Co des and St andards where Indian Codes are not available and which are equivalent to Indian Standards.

b) National Building Code of India.

c) "Accepted Standards" and "Good Practice" listed in the a ppendix to National Building Code of India.

d) IS-1200 : Method of measurement of Building and Civil Engineering Work.

e) IS-1256 : Code of Practice for Building Byelaws.

f) APDSS where ever a) to e) does not speak off.

3.01.01 **Earthwork**

a) IS-1498 : Classification and identification of soils for General Engineering purposes.

b) IS-3764 : Safety Code for excavation work.

c) IS-7293 : Safety Code for working with construction machinery.

3.01.02 **Concrete**

a) IS-269 : Ordinary and low heat portland cement.

b) IS-383 : Coarse and fine aggregate from natural sources for concrete.

c) IS-432 : Mild Steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement.

d) IS-455 : Portland Slag Cement.

e) IS-456 : Code of Practice for Plain and reinforced concrete.

f) IS-460 : Test Sieves (all parts).

g) IS-516 : Methods of test for strength of concrete.

h) IS-1199 : Methods of sampling and analysis of concrete.

i) IS-1566 : Hard dra wn steel wire fa bric for concrete Reinforcement.

| | | | |
|---|---|---|---|
| j) | IS-1786 | : | High stren gth deformed steel b ars and w ires for concrete reinforcement. |
| k) | IS-1834 | : | Hot applied sealing compounds for joints in concrete. |
| l) | IS-2386 | : | Methods of test for aggregates for concrete (all parts). |
| m) | IS-2502 | : | Code of practice for bending and fixing of b ars for concrete reinforcement. |
| n) | IS-3370 | : | Code of practice for concrete structures for sto rage of liquids (all parts). |
| o) | IS-3414 | : | Code of pra ctice for de sign and installation of joints in buildings. |
| p) | IS-4948 | : | Welded steel wire fabrics for general use. |
| q) | IS-6452 | : | High Alumina Cement for Structural use. |
| r) | IS-7320 | : | Concrete slump test apparatus. |
| s) | IS-7861 | : | Code of practice for extreme weather concreting (all parts). |
| t) | IS-8041 | : | Rapid Hardening Portland Cement. |
| u) | IS-8112 | : | High strength ordinary Portland Cement. |
| v) | IS-10262 | : | Recommended guidelines for concrete mix design. |
| w) | IS-12269 | : | 53 grade ordinary Portland Cement |

3.01.03 **Foundations**

| | | | |
|---|---|---|---|
| a) | IS-1904 | : | Code of practice for structural saf ety of buildings : Shallow foundations. |
| b) | IS-2950 | : | Code of practice for design and construction of raft foundations. |
| c) | IS-2974 | : | Code of p ractice f or design and constru ction of Machine foundations (all parts). |
| d) | IS 2911 | : | Code of practice for D esign and Construction of Pile Foundation. |

3.01.04 **Loading**

| | | | |
|---|---|---|---|
| a) | IS-875 | : | Code of practice for Structural safety of buildings - loading standards. |
| b) | | : | Bridge Rules of Government of India, Min istry of Railways (Railway Board). |
| C) | IS 4995 | : | Criteria for design of RC bins for storage of granular and powdery materials. |

3.01.05 **Masonry**

| | | | |
|---|---|---|---|
| a) | IS-712 | : | Building limes. |
| b) | IS-1077 | : | Common Burnt Clay Building Bricks. |
| c) | IS-1127 | : | Recommendations for dimensions and workmanship of natural building stones for masonry work. |
| d) | IS-1528 | : | Methods of sampling and physical tests for refractory materials. |
| e) | IS-1597 | : | Code of practice for construction of stone masonry (all parts). |
| f) | IS-2212 | : | Code of practice for brickwork. |
| g) | IS-2116 | : | Sand for masonry mortars |
| h) | IS-2185 | : | Concrete masonry units.<br>(all parts - Hollow and Solid concrete blocks). |
| i) | IS-2250 | : | Code of practice for preparation and use of masonry mortars. |
| j) | IS-2572 | : | Code of practice for construction of hollow concrete block masonry. |
| k) | IS-2691 | : | Burnt clay facing bricks. |
| l) | IS-3414 | : | Code of pra ctice for de sign and installation of joints in buildings. |
| m) | IS-3495 | : | Methods of tests of burnt clay building bricks. |
| n) | IS-4441 | : | Code of practice for use of Silicate type chemical resistant mortars. |
| o) | IS-4860 | : | Acid Resistant Bricks. |

3.01.06 **Doors, Windows and Ventilators**

| | | | |
|---|---|---|---|
| a) | IS-399 | : | Classification of commercial t imbers and their zonal distribution. |
| b) | IS-883 | : | Code of practice for design of structural timber in building. |
| c) | IS-1003 | : | Timber paneled and glazed shutters (all parts). |
| d) | IS-1038 | : | Steel doors, windows and ventilators. |
| e) | IS-1081 | : | Code of pra ctice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators. |
| f) | IS-1361 | : | Steel windows for industrial buildings. |
| g) | IS-2835 | : | Transparent sheet glass for glazing and framing purposes. |
| h) | IS-1948 | : | Aluminium doors windows and ventilators. |
| i) | IS-1949 | : | Aluminium windows for industrial building. |
| j) | IS-2191 | : | Wooden flush door shutters (Cellular and hollow core type). |
| k) | IS-2202 | : | Wooden flush door shutters (solid core type). |
| l) | IS-3103 | : | Code of practice for Industrial ventilation. |
| m) | IS-3548 | : | Code of practice for glazing in buildings. |
| n) | IS-3614 | : | Fire check doors. |
| o) | IS-4021 | : | Timber door, windows and ventilator frames. |
| p) | IS-4351 | : | Steel door frames. |
| q) | IS-6248 | : | Metal rolling shutters and rolling grills. |

3.01.07 **Roof and Flooring**

| | | | |
|---|---|---|---|
| a) | IS-2204 | : | Code of practice for construction of reinforced concrete shell roof. |
| b) | IS-3201 | : | Criteria for the design and construction of precast concrete trusses. |
| c) | IS-2210 | : | Criteria for Design of R.C. shell str uctures and folded plates. |
| d) | IS-809 | : | Rubber flooring materials for general purposes. |
| e) | IS-1195 | : | Bitumen mastic for flooring. |
| f) | IS-1196 | : | Code of practice for laying bitumen mastic flooring. |
| g) | IS-1198 | : | Code of practice for laying, fixing and maintenance of linoleum floors. |
| h) | IS-1237 | : | Cement concrete flooring tiles. |
| i) | IS-1443 | : | Code of practice for laying and finishing of cement concrete flooring tiles. |
| j) | IS-2114 | : | Code of practice for laying in situ terrazzo floor finish. |
| k) | IS-2571 | : | Code of practice for laying in situ cement concrete flooring. |
| l) | IS-5491 | : | Code of practice for laying in situ g ranolithic concrete floor topping. |
| m) | IS-5766 | : | Code of practice for laying burnt clay brick flooring. |
| n) | IS-1197 | : | Code of practice for laying of rubber floors. |
| o) | IS-2441 | : | Code of practice for fixing ceiling coverings. |

3.01.08 **Waterproofing**

| | | | |
|---|---|---|---|
| a) | IS-1322 | : | Bitumen felts for waterproofing and damp proofing. |
| b) | IS-1346 | : | Code of practice for waterproofing of roofs with bitumen felts. |
| c) | IS-1609 | : | Code of pra ctice for laying damp proof treatment using bituminous felts. |

d) IS-3036 : Code of practice for laying lime concrete for a waterproofed roof finish.

e) IS-3037 : Bitumen mastic for use in waterproofing of roofs.

f) IS-3067 : Code of practice for general design, details and preparatory work for damp proofing and water proofing of buildings.

g) IS-3384 : Bitumen primer for use in water proofing and damp proofing.

h) IS-4365 : Code of practice for application of bitumen mastic for waterproofing of roofs.

3.01.09 **Soil Engineering**

a) IS-1498 : Classification and identification of soils for general engineering purposes.

b) IS-1892 : Code of practice for sub-surface investigation for foundations.

c) IS-2131 : Method for standard penetration test for soils.

d) IS-2720 : Methods of test for soils (all parts).

3.01.10 **Water Supply, Drainage and Sewerage**

a) IS-404 : Lead pipes

b) IS-458 : Concrete pipes

c) IS-651 : Salt glazed stoneware pipes and fittings.

d) IS-771 : Glazed fire-clay sanitary appliances (all parts).

e) IS-774 : Flushing cisterns for water closets and urinals other than plastic cisterns.

f) IS-783 : Code of practice for laying of concrete pipes.

g) IS-1172 : Code of basic requirements for water supply, drainage and sanitation.

h) IS-1626 : Asbestos cement building pipes, gutters and fittings (all parts).

| | | | |
|---|---|---|---|
| i) | IS-1742 | : | Code of practice for building drainage. |
| j) | IS-2064 | : | Code of practice for selection, installation and maintenance of sanitary appliances. |
| k) | IS-2065 | : | Code of practice for water supply in buildings. |
| l) | IS-2470 | : | Code of practice for installation of septic tanks (all parts). |
| m) | IS-3114 | : | Code of practice for laying of Cast Iron pipes. |
| n) | IS-4127 | : | Code of practice for laying of glazed stoneware pipes. |
| o) | IS-12251 | : | Code of practice for Drainage of Building Basement. |
| p) | IS-1200 | : | Method of measurement: Laying of water and [Part-XVI] sewer lines including appurtenant items. |
| q) | IS-1536 | : | Centrifugally cast (spun) iron pressure pipes for water, gas and sewage. |
| r) | IS-1537 | : | Vertically cast iron pressure pipe for water, gas and sewage. |
| s) | IS-3486 | : | Cast iron spigot and socket drain pipes. |
| t) | IS-5329 | : | Code of practice for sanitary pipe work above ground for buildings. |
| u) | IS-3076 | : | Low densit y polyethyl ene pipes for potable water supplies. |
| v) | IS-1538 | : | Cast iron fitt ings for pressure pipes for water, gas and sewage. |
| w) | IS-1230 | : | Cast iron rainwater pipes and fittings. |
| x) | IS-1729 | : | Sand cast iron spigot and socket soil, waste and ventilating pipes, fittings and accessories. |
| y) | IS-784 | : | Prestressed concrete pipes. |
| z) | IS-1726 | : | Cast iron manhole covers and frames. |
| aa) | IS-5961 | : | Cast iron grating for drainage purposes. |
| bb) | IS-5219 [Part-I] | : | "P" and "S" traps. |

cc) IS-772 : General requirements for enamelled cast iron sanitary appliances.

dd) IS-775 : Cast iron brackets and supports for wash basins and sinks.

ee) IS-777 : Glazed earthenware wall tiles.

ff) IS-2548 : Plastic water closet seats and covers (all parts).

gg) IS-2527 : Code of practice for fixing rainwater gutters and downpipes for roof drainage.

3.01.11 **Paving and Road work**

a) IS-73 : Paving bitumen

b) IS-702 : Industrial Bitumen

c) IS-1201 : Method of testing tar and bituminous materials. thru' 1220

d) Practice followed by Indian Road Congress (all parts).

3.01.12 **Earthquake Resistant Design**

a) IS-1893 : Criteria for earthquake resistant design of structures.

b) IS-4326 : Code of practice for earthquake resistant design and construction of buildings.

3.01.13 **Chimney**

a) IS-4998 : Criteria for Design of R.C. Chimneys (all parts).

3.01.14 **Structural Steelwork**

a) IS-800 : Code of practice for general construction in steel.

b) IS-802 : Code of practice for use of structural steel in Overhead Transmission Line.

Part-I : Load and permissible stresses.

Part-II : Fabrication, Galvanizing, Inspection & Packing.

c) IS-806 : Code of practice for use of steel tubes in general building construction.

| | | | |
|---|---|---|---|
| d) | IS-808 | : | Rolled steel beams, channels and angle sections. |
| e) | IS-813 | : | Scheme of symbols for welding. |
| f) | IS-814 | : | Covered electrodes for manual metal arc welding of carbon and carbon manganese steel. |
| g) | IS-816 | : | Code of practice for use of metal arc welding for general construction in mild steel. |
| h) | IS-817 | : | Code of practice for training and testing of metal arc welders. |
| i) | IS-818 | : | Code of practice for safety and health requirements in electric and gas welding and cutting operation. |
| j) | IS-819 | : | Code of practice for Resistance spot welding for light assemblies in Mild Steel. |
| k) | IS-919 | : | Recommendations for limits and fits for engineering. |
| l) | IS-1024 | : | Code of practice for use of welding in Bridges and Structures subjected to Dynamic loading. |
| m) | IS-1161 | : | Steel tubes for structural purposes. |
| n) | IS-1182 | : | Recommended practice for Radiographic Examination of Fusion Welded Butt joints in steel plates. |
| o) | IS-1200 [Part-VIII] | : | Method of measurement of steelwork and ironwork. |
| p) | IS-1239 | : | Mild steel tubes, tubulars and other wrought steel fittings (all parts). |
| q) | IS-1363 | : | Black hexagonal bolts, nuts and locknuts (dia. 6 to 39 mm) and black hexagon screws (dia.6 to 24 mm). [all parts] |
| r) | IS-1364 | : | Precision and semi-precision hexagon bolts, screws, nuts and locknuts (dia. range 6 to 39 mm). [all parts] |
| s) | IS-1365 | : | Slotted counter sunk head screws (dia. range 1.6 to 20 mm). |
| t) | IS-1367 | : | Technical supply conditions for threaded steel fasteners. |

| | | | |
|---|---|---|---|
| u) | IS-1443 | : | Code of practice for laying and finishing of cement concrete flooring tiles. |
| v) | IS-1608 | : | Method for tensile testing of steel products. |
| w) | IS-1730 | : | Dimensions for steel plate, sheet and strip for structural and general engineering purpose. |
| x) | IS-1731 | : | Dimensions for steel flats for structural and genera l engineering purposes. |
| y) | IS-1852 | : | Rolling and cutting tol erances for hot rolled steel products. |
| z) | IS-1977 | : | Structural steel (Ordinary quality) |
| aa) | IS-2016 | : | Plain Washers |
| bb) | IS-2062 | : | Steel for General structural purposes. |
| cc) | IS-2074 | : | Ready mi xed paint, a ir drying, red oxide zinc-chrome, priming. |
| dd) | IS-2633 | : | Methods of testing unifo rmity of coa ting of zin c coated articles. |
| ee) | IS-3613 | : | Acceptance tests for wire-flux combinations for submerged-arc welding of structural steels. |
| ff) | IS-3664 | : | Code of practice for U ltrasonic Pu lse echo te sting by contact and immersions methods. |
| gg) | IS-3757 | : | High strength structural bolts. |
| hh) | IS-4000 | : | High strength bolts in steel structures. |
| ii) | IS-4759 | : | Hot dip zinc coatings on structural steel and other allied products. |
| jj) | IS-5334 | : | Code of practice for Magnetic Particle Flaw detec tion of welds. |
| kk) | IS-7215 | : | Tolerances for fabrication of steel structures. |
| ll) | IS-7280 | : | Base-wire electrodes f or sub-merged arc welding of structural steels. |
| mm) | IS-7318 [Part-I] | : | Approval test for welders when welding procedure approval is not required. |

nn) IS-8500 : Structural steel – micro-alloyed (medium an d high strength qualities).

oo) IS-9595 : Recommendation for m etal arc welding of carbon and carbon manganese steels.

pp) AWS D.1.1 Structural Welding Code.

3.01.15 **Painting**

a) IS-348 : Specification for French Polish.

b) IS-427 : Specification for Distemper, dry colour as required.

c) IS-428 : Specification for Distemper, oil emulsion, colour as required.

d) IS-1477 [I & II] : Code of practice for painting of ferrous metal in buildings.

e) IS-2338 [I & II] : Code of practice for finishing of wood and wood based materials.

f) IS-2339 : Specification for Aluminium Paints for general purposes in dual containers.

g) IS-2395 : Code of practice for painting concrete, masonry and plaster surface.

h) IS-2932 : Specification for enamel, synth etic, exterior - a) undercoating, b) finishing.

i) IS-2933 : Specification for enamel, exterior - a) undercoa ting, b) finishing.

j) IS-5410 : Specification for cement paint.

3.01.16 a) Indian Road Congress (IRC) Bridge Codes

b) Indian Railway Standard Bridge Rules

3.01.17 **Environmental Protection**

Chapter on Corporate Responsibility for Environmental Protection (CREP) published in Gazette of India dated 27.08.2003.

## 4.00.00 UNITS AND LANGUAGE

### 4.01.00 Drawings

- All dimensions will be in SI Units - Metric (English)
- Scales
  - Planning Drawings: Site Layout & Elevations will be at 1:500, Section & Elevation of each building will be at 1:200.
  - Structural and architectural Plans, sections, and elevations will generally be at 1:100 and/or 1:50; for architectural and civil details; 1:1, 1:5, 1:10, 1:20 as required will be used.
  - Site work and yard piping plans will generally be at 1:200, 1:500
- Text will be in English language

### 4.02.00 Units for Calculations

All calculations will be in SI (English) units.

| | |
|---|---|
| Length | mm, M |
| Area | $mm^2$, $M^2$ |
| Volume (solids) | $mm^3$, $M^3$ |
| Volume (liquids) | $mm^3$, $M^3$, liter |
| Density | $kN/M^3$ |
| Force | N, kN |
| Pressure (piping) | Bar |
| Moment | kNM |
| Stress | Mpa, $N/mm^2$ |
| Distributed loads, ground pressures, etc. | $kN/M^2$ |

English language will be used in calculations

## 9.00.00 BUILDING DESIGN CONCEPT

### 9.01.00 Framing System and Method of Analysis

Analytical model of the building stru cture will be either two dimensional or a three dimensional spa ce frame. Analysis of models sh all be done using STAAD Pro Software.

For Steel frame structure, it will b e either (1) Simple frames with vertica l diagonal bracings at column lines in both dire ctions and hor izontal bracing at the roof and major floo r levels or (2) Mo ment resisting fra me in trans verse direction wit h braced frames in longitudinal d irection. For Concrete frame structure, it will be Moment resisting frame in both directions.

For composite framed building moment resisting frame will be provided in transverse and longitu dinal dire ction with rein forced con crete column s and steel roof truss/girder fr aming members in transverse direction and reinforced concrete framing members in longitudinal direction.

### 9.02.00 Method of Design

The Strength design of Steel members will be done by working / a llowable stress method using IS:800 (Latest Edition) where as the Strength design of Concrete members will be done by limit state method using IS:456 (Latest Edition).

Un-braced lengths for steel beams will be as per code or as determined from following criteria

- Beams supporting concrete slab wit h shear con nectors / compression flange emb edded in RCC slab will be considered continuously supported.
- Beams supporting metal roof deck attached with welding washers plug welded will be considered continuously supported.
- Beams sup porting met al deck or concrete slabs formed with metal decking will have an u n-braced le ngth based on framing member locations.
- Beams supporting grating floor will not be co nsidered co ntinuously supported.
- Beams which are part of a truss will use t he distance betwe en panel points as their un-braced length or, if the p anel has connecting major members, the un-braced length will be based on the distance between panel point s or connecting members, whi chever is the shorter distance.

- In grating floor, for two parallel, in terconnected beams, the beam with greater load will be con sidered as un-braced and the other beam as braced at the points of interconnection

- In grating floor, for three or more parallel, inter connected beams with loads of sa me order or magnitude, all beams will be considered as braced at points of intersection s. When the beams are loaded disproportionately, the un-braced lengths will be determined as sta ted above.

- **Acceptance Criteria for required depth**

  - For steel members, minimum dept h equals to 1/24 of sp an unless clearance requi rements will dictate lower depth in certain areas.

  - For Concrete members, minimum depth equals to 1/16 of span unless clearance requi rements will dictate lower depth in certain areas.

  - Members will be frame d into members of equ al or great er depth

## 10.00.00 DESIGN OF REINFORCED CONCRETE STRUCTURES

a) The design of R.C. Structures sha ll be carried out by limi t state or working stress method as per the provisions of IS-456.

Concrete tanks/water retaining structures shall be designed in accordance with the recommendation of IS-3370.

b) For reinforcement detailing IS:552 5 and SP:34 shall be followed. Ductile detailing of RCC structures will be as per IS: 13920.

c) The walls shall be pr ovided with reinforcement on bot h faces for sections 150 mm or more, even if not required from design consideration.

d) **Liquid Retaining Structures**

RCC water retaining structure like storage tanks, reservoirs, etc. shall be leak pro of and designed as un cracked section in accor dance with IS:3370 (part I to IV) by working stress method.

Substructure of pump houses shall be design ed as cracked section with limiting crack width of 0.1 mm and limiting steel stresses as per IS:3370 (Part I to IV) by working stress method for concrete face away from water/l iquid. For f aces in co ntact with water/liquid th e structure shall be designed as un cracked se ction in acco rdance with IS: 3370 (part I to IV) by working stress method.

All water retaining / sto rage structu res shall be designed a ssuming liquid up to the height of wall irre spective of provision o f any over flow arrangement. No pressure relievin g devices shall be pe rmitted in underground structures.

In all liquid retaining str uctures lea k-tightness shall be en sured and guaranteed. To achieve the same, methodo logy in de sign an d construction in the way of providing PVC water bars at construction/expansion joints and /or inject ion grouting, usage of admixture i n concrete or any such method sh ould be adopted. The sequence of construction shall also be specified on drawing s showing construction joints.

10.01.04 **Other Requirements**

i) In case of high ground water table, for excavations comprehensive dewatering arrangement shall be required. Scheme for dewatering and design with all computations and back-up data of dewatering and sheet pilling shall be submitted for Owner's information.

ii) The founding level for trenches/channels shall be decided as per functional requirement. The bottom of excavation shall be properly compacted prior to casting of bottom slab of trenches/channels.

iii) Excavation for open foundations shall be covered with PCC immediately after reaching the founding level. In case of any local loosening of soil at founding level during excavation, the same shall be removed and compensated by PCC. The foundation pits shall be maintained dry during the complete construction period by means of suitable dewatering systems.

iv) Backfilling, around foundations and bottom of pipes, thrust blocks, etc. shall be carried out with approved material in layers not exceeding 30 cm thickness and each layer shall be compacted to 90% standard proctor density for cohesive soil and to 75% of relative density for non-cohesive soils.

v) Excess/surplus excavated material shall be disposed off by the EPC Contractor as per the instructions of the Owner up to a lead of about 5 km crow fly distance from the plant site.

vi) CBR tests for flexible pavement design shall be carried out by the EPC Contractor after earth filling has been completed, if applicable.

vii) The storage tanks shall rest on flexible tank pad resting on an open/shallow foundation or pile foundation. The tank pad shall be made of two layers. The first layer shall be thoroughly compacted fill of gravel, coarse sand or other suitable material topped with minimum 75mm thick compacted crushed stone, screenings, fine gravel, clean sand or similar material mixed in hot asphalt (80 / 100 bitumen or equivalent 8 to 10% by volume), rolled and compacted. The second layer shall be with minimum 25 thick premix carpet with 12 mm and down broken stone chips and 80/100 grade hot bitumen. The tank pad shall be laid by an expert agency having wide experience in execution of similar work. The tank pad shall be made up from founding level to the required level by controlled compaction in layers of 200 mm to achieve a relative density of 85% using suitable compaction equipment approved by the Owner. In addition to the above, in case of an open/shallow foundation, a ring wall shall be provided adjacent to the tank wall for retaining the fill below tank. The foundation system shall be designed as per the provisions of IS: 803. The tank shall have a flexible bottom plate, which shall establish complete bearing with the foundation fill.

After the tanks have been erected, hydro testing shall be done. Subsequent upon hydro testing of tank, the differential settlement.

10.02.00 **General Requirements**

- **Minimum Thickness of Structural Elements**

The following minimum thickness shall be followed :

| | |
|---|---|
| Pile caps | 900 mm |
| Suspended floor / slab / walkways / canopy slabs, etc | 150 mm |
| Ground floor slab (non-suspended) | 150 mm |
| Water Retaining slabs / walls | 200 mm |
| Cable / pipe trenches / underground pits / Launder walls and base slab | 125 mm |
| All footings (including raft foundations) | 300 mm |
| Width of beam | 150mm |
| Parapets | 125 mm |
| Sunshades at edge | 75 mm |
| Pre-cast louvers / fins | 50 mm |
| Pre-cast trench cover slabs / floor slabs / louvers | 75 mm |
| Paving | 150 mm |
| Basement walls and base slab | 200 mm |
| Silo / bin walls | 150 mm |
| Underground reservoir Below ground water table | 200 mm |
| Above ground water table | 150 mm |

From fire re sistance point of view minimum fire rating o f 2 hours shall be considered where fire hazard is expected and minimum thickness of reinforced concrete members shall be as per fig 1 and table 16a of IS 456 or specified above, whichever is higher.

- **Concrete Cover**

  Following minimum clear concrete cover to steel reinforcement will be provided.

| A. | **Substructure Work** | Bottom | Sides | Top | Ends |
|---|---|---|---|---|---|
| i) | Foundation | 75 | 50 | 50 | 50 |
| ii) | Columns, Pedestals, Grade Beams/Tie Beam | 50 | 50 | 50 | 50 |
| iii) | Trenches, Pits, Walls, Duct Bank etc. in contact with | | | | |
| | Earth | 50 | 50 | 50 | 50 |
| | Water | 50 | 50 | 50 | 50 |
| | Others | 25 | 25 | 25 | 40 |
| iv) | Equipment Foundations | 50 | 50 | 50 | 50 |
| v) | Slab on Grade | 25 | 50 | 25 | 50 |
| B. | **Super structure Work** | | | | |
| i) | Columns | - | 40 | - | - |
| ii) | Beams | 35 | 35 | 35 | 50 |
| iii) | Slabs/Walls | 20 | 20 | 20 | 40 |
| iv) | Lintel, Chajja, Bands etc. | 20 | 20 | 20 | 25 |
| v)<br>vi) | Pre-cast Concrete<br>Silo shell side cover | 20 | 20<br>30 | 20 | 20 |

- **Minimum Heights For Pedestals/Encasements of Steel Columns**

  Pedestals to Steel Columns for building structures

  In case the top of pedestal is kept at a lower level so that the column base plate together with gussets and stiffeners remain below finished floor level ( FFL) the column bases as well as the column sections shall be encased in concrete above FFL as per following.

  a) Open area : 300 mm above paved level

  b) Covered area : 300 mm above FFL

  Stair and ladder pedestal shall be kept 200 mm above the finished floor level.

  Pedestals to Steel Columns for Equipment structure :

  a) Equipment in open area : as required (300mm min)

  b) Equipment in covered area : as required (150 mm min)

c) Structures and equipment supplied by vendor : as per vendor's data subject to minimum as specified above

Foundation levels for some columns may be changed suitable to accommodate underground services, pits, trenches etc.

- **Ground floor slab-on-grade**

Ground floor slab-on-grade shall be RCC with Vaccum Dewatered Flooring (VDF) concrete construction laid over minimum 100mm thick lean concrete. Minimum 250mm thick graded stone (63 mm down size) soling with interstices filled with sand/gravel and compacted mechanically, shall be provided as sub-base below lean concrete. The sub-base shall be laid over rammed and well-compacted earth fill or hydraulically compacted sand fill as specified elsewhere in this specification.

- **Stairs, Platforms, Ladders and Handrails**

All internal stairs, platforms and walkways shall either be of RCC or GI gratings construction. All outdoor stairs, platforms and walkways shall either be of RCC or minimum 40mm thick grating. Stairway in a single run shall have the same slope. The vertical rise of the stairways shall not exceed 3.0 mm for a single flight. . All stairs shall have a maximum riser height of 125 mm and a minimum tread width of 250mm. Minimum width of stairs in all buildings shall be 1200 mm.

Hand railing comprising of posts 1000 mm (min.) high not exceeding 1.5m (max) c/c, shall be provided around all floors/ roof openings, projections, balconies, walkways, platforms, steel stairs etc. All hand rails and posts shall be 32NB heavy duty GI pipes as per relevant IS Codes and shall be galvanized with class-1 galvanization (as per IS-277) shall be provided for all structural steel stair cases and external RCC stairs. Hand rail will be provided with one horizontal pipe at mid-height and continuous flat iron toe guard at bottom. For all internal RCC stair cases in buildings, stainless steel hand railing shall be provided. For stainless steel handrail refer relevant architectural specification.

Steel cage ladder shall be hot dip galvanised. Stringers shall be of angles 90x90x10 with a minimum clear distance of 400 mm in-between. Rungs shall be of 20 mm diameter mild steel rods spaced at 300 mm centres. Ladder stringers shall be provided with suitable lateral stays. The ladder and its connection shall be designed for a minimum load of 200 kg at any location. Cage shall start from a height of 2.5 m above the base of ladder.

11.00.00 **DESIGN OF STEEL STRUCTURES**

a) Structural steel design shall be carried out as per the National Building Code with specific co nsultation t o IS-800 working stress method unless no ted otherwise. Design of structures in electrical substation shall be as per IS-802.

b) Lateral forces along the length of the building shall be resisted by bracings in horizontal and vertical frames. The transverse lateral load shall be resisted by stif f jointed fra me action. Additional bracing or moment connection shall be used to assure stability of the structures.

c) Vertical bra cing membe rs which are connected to the beam shall be analyzed for all the vertical loads which the beam is subjected to along with lateral loads.

d) Shear force in steel columns shall be transferred to the pedestals/ foundations exclusively either through foundations bolts o r through shear key arrangement.

Design of base plate shall be ba sed on the design pr essure on foundation which shall not exceed the following:

i) Pedestal in concrete grade M20 …….5.0 N/mm$^2$

ii) Pedestal in concrete grade M25 …….6.25 N/mm$^2$

iii) Pedestal in concrete grade M30 …….7.5 N/mm$^2$

e) Shop connections sha ll be all welded and field connections shall generally be bolted unless specif ied otherwise. Field bolts, wherever provided shall be high tensile of 20 mm dia. or of higher d iameter and of property class 8.8 a s per IS-1367 for all major connections. The bolted joints shall be designed for friction type connection and the H.T. bolts shall be tightened to develop the required pretension during their installation. However, the nominal connections in the field like purlins, stairs, wall beams etc. shall be done by 16 mm dia. M.S. black bolts (minimum 4.6 grade) conforming to IS-1 363 unless specified otherwise.

f) Welding shall be in accordance with the recommendations of IS-816 - Code of Practice for u se of metal arc welding fo r general co nstruction in mild steel and IS-9595 - Recommendation for Metal Arc Welding of Carbon and Carbon Ma nganese Steels. Built- up members shall be fabricated using submerged arc wel ding procedure unless manual arc welding is specifically required. All butt weld s in p late g irders and columns shall be fu ll penetration. All b utt welds shall be radiographically or ultrasonically tested as per r elevent IS codes and standard practice. The bare wire electrodes for submerged arc welding shall be as follows

Filler wire: AWS-A-5.17-EH14
Flux shall be agglomerated type of classification
AWS-A-5.17 -F7A2EH14

g) All structural steel members for substation shall be hot dip galvanised in accordance with IS-4759. The fasteners shall also be galvanised in terms of IS-5358. Galvanizing of steel structure shall be done after all fabrication work is completed. Zinc coating of galvanized surface of structural members and threaded fasteners shall as recommended in IS:4759. However, fasteners may be tapped or re-run after galvanizing. Threads of bolts and nuts shall be capable of developing the full strength of the bolt. The spring washers shall be electro-galvanized as per IS-1573. All galvanizing shall be uniform and of standard quality and shall withstand tests in accordance with IS-2633.

h) Shop primer paint shall be single coat of epoxy resin based zinc rich primer (such as blast steel EZ1 of Shalimar Paints Ltd.). The surface preparation shall be done after sand blasting in accordance with IS: 1477 (Part I & II) – Code of Practice for Finishing of Ferrous Metals in Buildings. Second coat of primer shall be applied after erection and final alignment of the erected structures. Two or more coats of epoxy paint of approved shade and quality shall also be applied after erection. Total Dry film thickness of the finished paint shall not be less than 110 microns.

i) All welding electrodes shall be of Low Hydrogen type conforming to IS:814 and shall be EB5426H3JX type. All electrodes, flux , wire etc. shall be of ADOR Welding Ltd.,or ESAB India Ltd., or D & H Secheron Electrodes Pvt. Ltd or Modi electrodes or equivalent as approved by Owner.

If submerged arc welding is used, the bare wire electrodes shall be as follows :

Filler wire : AWS-A-5.17-EH14

Flux : agglomerated type of classification
AWS-A-5.17 -F7A2EH14

j) Minimum preheat & inter pass temperatures for welding over 40mm to 63mm (thickness of the thicker part at the point of welding) shall be 66°C and for over 63mm, it shall be 110°C. However, higher preheat & inter pass temperatures may be required due to joint restraint etc. and shall be followed as per approved welding procedure.

k) Minimum te sts to be carried out during fabrication and erection of structural steel shall be as follows:

**Steel**

Ultrasonic Test: Plate s above 25mm thick shall be subjected t o ultrasonic test as per ASTM-A435 or equivalent to check the presence of lamination.

**Fillet weld**

Dye Penetration Test: 25% of the total length, Dye penetration shall be carried out to the root run.

**Butt weld**

Dye Penetration Test : 100% of the total length, Dye penetration shall be carried out to the root run after back gouging

Radiographic Test: Splicing should not be provided in tension flange of Bunker Girders and crane girders. Spot radiography shall be carried out on 100% joints in t ension zone. Minimu m 300mm length shall be spot radiogr aphed. When radiogra ph is not p ossible ultra sonic te st shall be carried out after grinding the surface.

100% radio graphy test shall be carried out f or the plate s of 32mm thick and above.

25% radiography test shall be carrie d out for the plates below 32m m thick.

100% radiography test shall be car ried out of t he crane girders and bunker girders irrespective of thickness of the plate.

Ultrasonic Test : 10% of all other Butt welds except crane girder and bunker gird er shall be subject to spot radiographic test an d the ent ire balance butt weld for ultrasonic test.

l) **Connections**

Connection of vertica l bracings with connecting members and diagonal tru ss members shall be de signed for f ull tensile capacity of the bracings.

Size of fillet weld for flange to web connectio n for built u p column section shall be as follows:

Full shear capacity for box section.

80% of full shear capacity or actual shear (if indicated in dra wings) or 0.5 times of the web thickness which ever is more for I section. Weld shall be double fillet.

All welds shall be continuous. The minimum size of fillet weld shall be as per relevant IS code. Shear connections sha ll be designed for 75% of section strength for r olled sections and 80% of se ction strength for built up se ction or rolled section wit h cover plates. Design shear force should be more than actual shear.

Moment connections between beam and column shall be designed for 100% of moment capacity of the beam section.

All butt welds shall be full penetration butt welds.

Connection of base plate & gusset members with the columns shall be done considering that total load gets transferred through weld.

Erection joints shall be provided with suitable splice pla tes as pe r design after conducting the relevant weld tests for the welded joints. All splicing work shall be of full stre ngth. Shop splicing for all sections other than rolled sect ions shall be carried out by full penetration butt welds. Shop splicing o f all rolled sections shall be carried out using web and flange cover plate.

Following connections shall be provided during erection :

**Welded Connection**

Connection of secondary beam to main beam

Connection of bracing to column

Connection of bracing to longitudinal tie beam

Connection of longitudinal tie beam to column

Connection of spandrel beam to column

Connection of other secondary structures

**HSFG Connection (Grade 8.8 bolts)**

Splicing of column/transverse frame beam/ longitudinal tie beam

Connection of frame beam to column

Connection of Crane Girder to column

Connection between crane girders

Other major connections

**Bearing Type Connection (HT bolts Grade 8.8)**

All removable type connections

M.S. bolts (Grade 4.6)

Purlins, stairs, wall beams etc.

11.01.00 **Other Specific Requirements**

All steel framed structures shall be either "rigid frame "or "simple space frames "or a combination of two.

Lateral forces shall be resisted by stiff jointed moment connections in rigid frame design. The column bases shall generally be fixed to concrete foundation pedestal by providing moment resistant base detail.

Simple space frame design utilises single-span beam systems, vertical diagonal bracing at main column lines and horizontal bracing at the roof and major floor levels.

Concrete floors shall be considered to provide continuous lateral support to the top (compression) flange of the support beams. However, wherever large cut outs (area more than 1.0 $m^2$) are provided in the floor slabs horizontal floor bracing shall be provided. Grating/ chequered plate floor shall neither be considered to provide lateral support to the top flange of supporting beams nor to provide a shear diaphragm. Adequate lateral support in the form of shear connector and horizontal bracing shall be provided as required.

Floors for vibrating machines of all kind together with supporting framework shall be adequately braced in both horizontal and vertical planes. Floors or structure supporting mechanical equipment shall be designed to minimise vibration, avoid resonance and maintain alignment and level.

All indoor gratings shall be electro forged type and outdoor gratings shall be welded type. Minimum thickness of grating shall be 40mm for indoor installation and 32mm for outdoor installation. The opening size shall not be more than 30mm x 100mm. The minimum thickness of the main bearing bar shall be 4mm. All gratings shall be hot dip galvanized.

Where a steel beam or member is to be connected on RCC structure, it shall be connected using an insert plate and through shear connection.

For crane girders, welding between web and flange plates shall be carried out by submerged arc welding process. Full penetration of weld between web plate and top flange shall be ensured. Intermediate stiffeners shall be connected with top flange plate by full penetration butt weld. Welding across tension flange shall not be permitted. Bearing edges of crane girders shall be machined.

The pipe and cable rack structures shall accommodate the pipes/cables with proper access and adequate working space for erection and maintenance. These shall be designed to carry safely all the loads acting on them (DL, LL, WL, EQL, forces from pipe lines etc.). The structures shall be adequately rigid to carry the forces from the pipelines at anchor points without undue deflection so that the pipe lines are really anchored at the anchor points.

The working point of the bracing connection shall be the center of column and girder to which it connects, where practical. The connections of gusset plates to column and girders shall be made to include provisions for eccentricity in connection. The double angle back-to-back with gusset plate in between shall not be used in dust-laden areas. Where double angles are not adequate, beam sections with web in the plane of bracing are used.

Permissible stresses for different members shall be allowed to exceed up to 33.33% only under normal loads along with wind and seismic conditions. However, members which are designed primarily to resist wind such as bracing members, no increase in permissible stresses shall be permitted. However, permissible stresses in bolts and welds shall be allowed to exceed up to 25 % only under wind and seismic conditions.

11.02.00 **Permissible Deflections**

The permissible deflections of various steel members under normal load conditions shall be as specified below. For calculation of deflections in structures and individual members dynamic effects shall not be considered, unless specified otherwise. Also, no increase in deflection limits shall be allowed when wind or seismic load are acting concurrent with normal loading conditions.

**Vertical Deflection**

| | | | |
|---|---|---|---|
| a) | For beams supporting dynamic equipment | : | Span / 500 |
| b) | For beams supporting floors/masonry | : | Span / 325 |
| c) | For beams supporting pipes ( pipe racks ) | : | Span / 400 |

d) For roofing and cladding components : Span / 250

e) For gratings and chequered plates : Span / 250 subject to a maximum of 6 mm

f) Coal conveyor gallery bridges: Span/450

For crane gantries or any member subjected to working loads, the maximum deflection under dead load and live load excluding impact shall not exceed the following values:

a) For manually operated cranes & monorails : Span / 500

b) For electric overhead cranes :

i) up to 50 t capacity : Span / 750

ii) over 50 t capacity : Span / 1000

**Horizontal deflections**

The permissible horizontal deflections shall be as per following unless specified otherwise:

a) Single storey building (without crane load ) : Height / 325

b) Multistoried building (without crane load) : Height / 500

c) Pipe rack columns : Height / 200

d) Open Structures : Height / 200

e) Crane gantry girder due to surge : Span / 2000 limited to maximum of 15 mm

f) Building main columns at crane rail level due to action of crane surge load only : Height / 2500 limited to maximum of 10 mm

g) Open gantry columns at crane rail level due to action of crane surge load only : Height/4000 limited to maxi mum of 10 mm

h) Coal Handling Trestles : Height/1000

Provisions of IS: 800 and relevant IS Code shall be followed for limiting deflections of structural elements not listed above.

11.03.00 **Minimum Thickness of steel elements**

The minimu m thickness of various components of a structu re and hot rolle d sections sh all be a s follows. The minimum thickness of r olled shape s shall mean flange thickness regardless of web thickness. Structural steel members exposed to significantly corrosive environment (Exposed to open air i.e., to Rain; Contact with Soil, Coal, ash, C ontact with drained liq uid or contaminated water, acid/alkali et c.) shall be in creased suit ably in thickness or suitably protected ot herwise as per good practice and sound engin eering judgment in each instance.

a) Trusses, purlins, girts and bracing : 6 mm

b) Columns and beams : 8 mm

c) Gussets : 8 mm

d) Stiffeners : 8 mm

e) Base plates : 10 mm & above

f) Chequered plates : 6 mm o/p & above

g) Grating flats : 5 mm

Minimum thickness of st ructural members other than gratin gs and ch equered plate direct ly exposed to weath er and inaccessible f or painting and maintenance shall be 8 mm.

11.04.00 **Minimum Sizes of steel elements**

For Joists : I - 150

For Channels : MC - 100

For Angles : L 50 x 50 x 6

Gusset plates : 8mm thick

| | | | |
|---|---|---|---|
| The flange width of purlins supporting light weight concrete slab | : | 65 mm |
| The flange width of purlins supporting roof sheeting and wall cladding | : | 50 mm. |
| Width of steel rolled section connected to other member | : | 50 mm. |
| The depth of beams for platform | : | 125 mm. |

11.05.00 **Slenderness and Depth Ratio**

The slenderness ratio of main members in tension, compression or bending shall be in accordance with IS: 800.

The following limiting ratios of depth to span shall be considered as a general guide.

| | | | |
|---|---|---|---|
| a) | Truss | : | 1 / 10 |
| b) | Rolled beams and girders for Ordinary floors and rafters | : | 1 / 24 |
| c) | Supporting floor beams for vibrating Machinery / equipment | : | 1 / 15 |
| d) | Roof purlins and girts | : | 1 / 45 |
| e) | Gable column | : | 1 / 30 |

12.00.00 **STRUCTURAL MATERIALS**

Following materials shall be used in design and construction of the structure and foundation:

12.01.00 **Structural Steel**

12.01.01 Structural steel shall conform to Grade A of IS: 2062 for rolled steel members or plates up to 20 mm thickness. For plates above 20 mm thickness and welded construction, steel conforming to Grade B (Killed and normalized) of IS: 2062 shall be used except for crane girders where Grade C (Killed and normalized) (IS: 2062) steel shall be used. All structural steel plates and sections shall be of Main producer such as " SAIL" or "TATA STEEL" or "RINL" or "JINDAL" make or vendor approved by owner.

12.01.02 Structural pipes conforming to IS 806 (YST 25)

12.01.03 Structural hollow sections (square & rectangular) conforming to IS:4923

12.01.04 Pipes of hand rail conforming to IS:1161 (Medium class Grade YST=240)

12.01.05 Plates, Flats, Ordinary steel washers conforming to IS:2062 (Grade A, B & C).

12.01.06 Steel Gratings – Carbon steel conforming to IS:2062.

12.01.07 Chequered plates (6 mm thick) – Carbon steel conforming to IS:3502.

12.01.08 Anchor Bolts, Studs or Threaded Bars – Mild Steel of grade 4.6 conforming to IS:5624.

12.01.09 Connection Bolts – All High strength connectio n Bolts shall be of grade 8.8 conforming to IS:1367 and shall be supplied conforming to IS:3757. All mild steel connection bolts shall be of grade 4.6 conforming to IS:1367.

12.01.10 All nuts sha ll be of heavy dut y he xagonal type and shall b e compatible with the bolts.

12.01.11 All nuts & washers for h igh strength bolts shall conform to IS:6623 & IS:6649 respectively.

12.01.12 Washers f or mild steel bolts shall be o f mild ste el conforming to IS:5369/IS:5372 or IS:5374 as the case may be.

12.01.13 Welding Electrodes – Low Hydrogen electrodes conforming to IS:814.

12.02.00 **Concrete**

12.02.01 **Cement**

All cement shall be Fly ash based Portland pozzolana ce ment conforming to IS:1489 (Part-1).

Ordinary po rtland cement conforming to IS:8112 (43 grade) / IS 122 69 (53 grade) shall necessarily be used for the following structures :

i) TG foundation top deck and sub-structure

ii) Major mac hine found ations su ch as PA/FD/ID Fans, Pulverizers, TDBFP AND MDBFP

iii) Chimney shell

iv) Shell and racker columns of NDCT

v) Structures r equiring gra de of concr ete of M25 and above excluding water-retaining structures.

As an alternative to Fly ash based Portland pozzolana cement, Fly ash can be added to ordinary Portland cement (Grade 43/53). Batching plant shall have facility for mixing fly ash. Fly ash shall conform to IS: 3812 (Part I & Part II). Percentage of fly ash to be mixed in concrete shall be based on trial mix and subject to maximum of 25% replacement of cement. Detailed design mix shall be carried out by the bidder and approved by the consultant / owner.

PP Cement shall be used only for miscellaneous buildings like storage sheds, concrete pavements. For all other works OP Cement (grade 43/53) shall be used.

The cement procured from mini plants will not be acceptable.

12.02.02 **Grade of Concrete**

The following minimum grades of concrete as per IS-456 shall generally be used :

| Sl. No. | Class | Grade of conc. |
|---|---|---|
| 1. | i) Plain cement concrete used for screeds and mud-mat<br><br>ii) Subgrade filling | M15<br><br>M7.5 |
| 2. | Paving in main plant area, Slab on grade, Duct bank | M20 |
| 3. | i) Reinforced concrete for super structure and foundation & Chimney raft | M25 |
| | ii) Reinforced concrete for water retaining structure | M25 |
| 4. | Pre-cast concrete | M30 |
| 5. | Reinforced concrete for foundation of TG, Mill, BFP & Fan foundations | M30 |
| 6. | TG top deck, chimney foundation | M30 |
| 7. | chimney shell | M40 |
| 8. | Piles | M30 |

Detailed design mix shall be carried out by the contractor and approved by the Engineer.

All underground trenches, basement and water retaining/conveying system structures shall have plasticiser cum waterproofing cement additives such as 'SIKA', 'FOSROC' make or equivalent conforming to IS:9103. In addition, limits on permeability as given in IS:2645 shall also be met with. Addition of admixtures should not reduce the strength of the concrete below the specified strength in any case. In case of water leakage during hydro-test or otherwise, additional chemical injection grouting treatment shall be applied for repairing the leakage with no cost implication to the owner.

All concrete surface in contact with soil shall be provided with minimum two coats of bituminous painting of grade 85/25 conforming to IS:702 @ 1.7 kg/sqm (minimum) for water / damp proofing up to 400 mm above finished grade level. Storm water drains shall not be provided with bituminous paint.

12.02.03 **Concrete Reinforcing Steel**

Reinforcing bars shall be TMT bars of grade Fe415 or Fe500 conforming to IS-1786 and Mild Steel bars conforming to IS : 432 (Grade I) of either of "SAIL", "TATA STEEL" and "RINL". However, for TMT re-bars above 25mm diameter shall be of 'SAIL', 'TATA' or 'RINL' only.

Furthur, vendor approval is required for additional vendors other than approved vendors of APGENCO.

14.04.00 **RCC Stack**

14.04.01 **General Arrangement**

The reinfor ced concre te single brick flue sta ck of 275 M height sha ll be comprising of a wind shield of rein forced con crete shell with insulated twin steel lining inside the wind shield from hopper level to top. The flue shall be vertically supported on pockects provided in wind shield at certain vertical spacing s d escribed elsewhere in this specification.
The externa l RCC platforms shall be supported on RCC win d shield. Access to the platforms shall be through cstaircase inside of chimney.

i) **General Parameters**

| | | |
|---|---|---|
| 1) | Total height of stack above ground level. | 275 M |
| 2) | Number of Stack (wind shield) | TWO |
| 3) | Number of flue per Stack | 2 |
| 4) | Number of Boilers | 4 (ONE FOR EACH UNIT) |

| | | |
|---|---|---|
| 5) | Particulate emission | 50 mg/$Nm^3$(approx) |
| 6) | Foundation level | To be decided by BHEL as per recommendation ba sed on geotechnical investigation carried out by bid der and a pproved by Owner |
| 7) | Allowable Soil Bearing Capacity | To be decided by BHEL as per recommendation ba sed on geotechnical investigation carried out by bid der and a pproved by Owner |
| 8) | Exit velocity of flue gas | 15 m/s with partial load<br>29.2 m/sec. with full load |
| 9) | Type of stack (wind shield) | RCC wind shield with twin steel flue |

ii) The wind shield shall be of RCC cons truction.
External RCC platforms shall be provided at regular in tervals satisfying all f unctional a s well as
statutory requirements. The flue ducts shall be entering the wind shield at a particular level.

All external RCC platforms shall be supported on R.C. shell of the wind shield. Access d oor at grade le vel
shall be provided for access into the windshield a nd to the hopper. All doors like inspection/maintenance doors shall be as per IS code / environment regulation.

Natural Ventilation within the windshield shall be provided as required.

iii) **Elevator and Caged Ladder**

Elevator inside Chimney and caged ladder as indicated in drawing shall be provided.

The travel of the elevator shall be u p to the last platform level. Caged ladder shall be provide d from last platform up to top level of chimney.

iv) **Paintings**

Entire external surface of the windshield shall b e painted at least two coats over prime coat in alternate band of signa l red and white colour starting wit h signal re d colour at the top an d in line with aviation requirements. External painting sha ll have acid, UV and he at resisting properties conforming to IS-158. Total dry film thickne ss ( DFT) shall be at lea st 150 micron s. The top of shell and top of acid resist ant bricks at the roof level shall be pain ted with two coats of 'EXPILUX 5 COAL TAR EPOXY PAINT" over a thin coat of the same paint a s manufactured by M/s. Berger Paints (India). The overall DFT shall be at least 230 microns.

The inner surface of wind shield fr om ground floor up to f ull height shall be painted with acid and he at resisting black bitumen paint (tw o coats) of a pproved ma ke to give a paint DFT not less than 150 microns .

Surface preparation and paint application shall be in accor dance with manufacturer's recommendation and as per specification.

v) **Flue Gas Sampling Ports on chimney**

a) Gas sampling ports fabricated from stainless steel with flanged ends sha ll be provided for liner at platform le vels, including proper insulation, blank plates, nut s, bolts et c. The location, orientation and levels of ports shall be as per the regulations of Central Pollution Control Board & Andhra Pradesh State Pollution Control Board.

b) Flue gas sampling ports for on line Emission monitoring instruments & Test Ports for l ocal sam pling & testi ng, fabricated f rom MS pi pes of sta ndard sche dule shall be provided on the liner at access platform level.

c) The contractor shall pro vide one (1) nozzle made of 200 NB MS pipe and projected approximately 200 mm outside the f lue wall with an upward inclination of 5 Degree with the horizon tal plane of flue can for mounting of SOx, NOx & CO analyzer.

d) The contractor shall provide two (2) nozzles in diametrically opposite po sition made of 200NB MS pipe and project ed approximately 200 mm outside the flue wall for mounting of Opacity monitor.

e) Location of the Sampling & Test ports, on the sta ck, shall be at least at a distance o f 8D (D= Stack diamet er) downstrea m along the direction of flu e gas flow from ID fan d uct connection to stack. F urther the selected po sition sha ll b e at lea st 2D before stack exit. The h eight of the test ports sh all not be less than 82.5 metre from FGL, fulfilling all above the criteria.

f) Temperature Test pockets with a stub of size M33 X2 for installing thermo-well shall be provided by Bid der for flue gas temperature measurement & correctio n for o pacity measurement.

g) In addition to the above sampling ports for instrumentation purpose there shall be four (4) gas sampling ports on t he flue can at 90 degree apart with flanged ends for local sampling & testing. Contractor shall provide required count er flange, n uts, bolts and gaskets. The size of each nozzle sh all be 100 NB and provided with blind flanges.

h) Access plat forms shall be provided for maintenance of t he above analyzers and for local sampling.

i) Power connection with 240V, 15A AC plug socket arrangement shall be installed at this platform level for ope rating the Test Instruments.

j) Dimensions indicated above are tentative, which shall be finalized during detail engineering upon receipt of vendor dat a. The exact details of pip e & flange and their elevations will be furnished d uring detail engineerin g on receipt of data from analyzer supplier.

Bidder shall furnish the arrangement drawings for the sampling and test points for Owner's approval during detail Engineering.

ii) **Maintenance Provisions**

The outer face of the chimney wind shield shall be provided with adequate number of stain less steel insert plates of grade 316 L at the top to enable fixing and supporting painter's trolleys and other accessories. The insert plates shall be provided with suitable number of threaded holes and nuts welded at the rear end to enable bolting of the assembly when desired.

Similar arrangement shall be made at each platform level but to fix the painting trolley arrangement directly on the platforms for the purpose of painting the chimney.

A lifting beam shall be provided to cater for lifting of materials during maintenance and painting. The size and capacity of the lifting beams shall be as per requirements.

iii) **Louvres**

Air outlet louvres shall be provided as per requirement. The louvre fins shall be of Z-shape in cross section and made from anodised aluminium plates of a minimum thickness of 4 mm. The frame work supporting the louvre fins shall be made from extruded aluminium sections of minimum thickness 6 mm. The louvres shall be mounted in the form of panels. The fins shall be closely spaced to cut off any driving rain entering the chimney wind shield. All panels must be approved by the Owner before installation.

14.04.02 **Design Criteria**

Design and construction of various components and systems of the chimney shall be in accordance with relevant Indian Standard and where provision s are not covered in IS, reference shall be made to ACI, BS, CI CIND and other international standards. In case of any conflict between this document and the Indian and International Standards, the stipulat ions of this document shall prevail.

A. **Loading**

a) **Dead Load**

i) All permanent loads due to the weight of chimney shell, external platforms, insulated brick linings supported on corbels, ladders, other accessories etc.

b) **Imposed Loads**

i) Imposed load on service platform around Chimn ey shell, sh all be taken as 500 Kg/m $^2$. Design live load dur ing constru ction / erection shall be considered as 1000 Kg/m$^2$.

ii) Imposed lo ads from duct jo ining the Chimney shall be considered.

c) **Wind Load**

The wind loading sha ll conform to IS: 87 5 (Part-3). Following parameters shall be considered for assessing wind loads:

Basic wind speed = 44 m/s at 10m above mean retarding surface

$k_1$ = 1.08 as per Table 1 of IS: 875 corresponding to 100 years return period

$k_3$ = 1.0

$k_2$ = As per Table 2 of IS: 875 (Part – 3) corresponding to terrain (category 4)

$k_2$ (bar) = As per Table 33 of IS: 875 (Part – 3) corresponding to terrain (category 4)

Aerodynamic Interferen ce Effect (p roximity effe ct) due to p resence of other tall stru ctures and stacks in the vicinity shall be asse ssed based on wind tunnel test to be carrie d by specialized agency in this fie ld acceptab le to Owner and shall be incorporated in design.

Profile (diameter, thickness etc.) as well as wind forces ( moment/shear etc.) at different sections/levels of chimney shall be calculated as per structural analysis conforming to requirements of IS:4998 and Contract Specification. Wind Tunnel study shall be carried out based on the profile of the chimney determined. Worst of the forces calculated as per structural analysis and obtained from wind tunnel study shall be considered as design forces for final design of shell and foundation.

d) **Seismic / Earthquake Load**

Calculation of earthquake forces acting on the Chimney and analysis for the same shall be carried out as per IS: 1893 (Part 4) [Zone – III] using the Response Spectrum Method. Material damping factor and number of modes to be considered for the analysis shall be as per recommendation in the code referred above.

e) **Thermal Effect**

Thermal effect due to established thermal gradient shall be duly considered as per provisions in relevant IS code.

The temperature gradient $\Delta$ T across the shell thickness of wind shield shall be calculated as per IS : 4998 but subject to a minimum of 30$^{o}$C. The temperature stresses shall be calculated according to the procedures given in ACI – 307 and IS : 4998.

f) **Local Loads**

The effect of following local loads shall be considered.

i) Local moment produced by corbels (if any).

ii) Local moment due to platforms.

iii) Local moment due to occurrence of ovalling oscillation.

iv) Local moment produced by thermal gradient.

B. **Load Combination**

Various load combination for calculation of stresses shall be as under.

i) Dead load + Wind load.

ii) Dead load + Earthquake effect.

iii) Dead load + Temperature effect.

iv) Dead load + Wind load + Temperature effect.

v) Dead load + Earthquake force + Temperature effect.

vi) Circumferential stresses due to temperature effect.

vii) Circumferential tensile stresses due to wind induced ring moment.

viii) Circumferential compressive stress due to wind induced ring moment combined with temperature.

In load combinations (i) to (viii) above, dead load considered with or without the weight of insulated brick lining, whichever condition is more critical shall be adopted for design. Across wind loads shall be combined with co-exiting along wind loads. The combined design moment at any section shall be taken as SRSS of the moments due to across wind loads and co-exiting along wind loads.

C. **Permissible Stresses For Chimney Shell**

The Stress in Steel reinforcement and Concrete shall not exceed the limits as prescribed in clause 7.0 of IS: 4998 (Part-2) for various combination of loads. Except for case of dead load + wind load, the maximum permissible stress in concrete in this case shall not exceed 0.28 Fc, where Fc = Characteristic compressive strength of concrete.

D. **Analysis**

- **Free Vibration Characteristics of Wind Shield**

  Assessment of Natural Frequencies and mode shapes shall be carried out. For this purpose the Chimney shell shall be idealized as a vertical cantilever with Lumped masses at different nodes. The nodes shall also be provided at each platform level.

  The number of modes to be considered in the analysis shall be such that at least 90% of the modal mass is excited.

- **Wind Analysis**

  a) **Along Wind Load**

  Along wind load shall be assessed based on methods specified in IS: 4998 (Part-I) – 1992. For design, higher of the wind loads obtained from simplified method in A-4.1 and random response method in A-5.1 shall be used. Dynamic modulus of Elasticity of concrete as recommended in IS: 4998 (Part-1) – 1992 shall be used for evaluating the natural frequencies.

Drag coefficient `$C_D$' or Force coefficient `$C_f$' shall be taken as 0.8 (minimum) based on Fig 5 of IS: 875 for the concrete shell in general. It will be increased as required as per IS: 4998 over the portion covered with strakes, if required. It is to be noted that provision of steel strakes may not be feasible considering the elevator and caged ladder up to top of chimney. Requirement of strakes shall be determined as per wind tunnel study.

b) **Across Wind Load**

The across wind response of the Chimney shall be evaluated as per the method given in Section A-4 as well as A-5 of IS: 4998 (Part-I) – 1992. Peak Oscillatory Lift Coefficient $C_L$ shall be taken as 0.16 and Strouhal Number $S_n$ as 0.2. Higher of the two moments shall be considered for design of the Chimney.

c) **Ring Moments due to Wind**

The circumferential ring moment due to wind shall be calculated in accordance with clause 5.4 of IS: 4998 (Part-I) – 1992. The wind induced stresses in concrete and steel shall be checked in accordance IS: 4998 (Part-2).

- **Seismic Analysis**

The Seismic Analysis shall be carried out using the Response Spectrum Method according to IS: 1893 taking the first 5 modes (minimum) of vibration in to account. 5% damping shall be considered for the analysis.

14.04.03 **Component Design Criteria**

A. **Wind Shield**

The design conditions for the concrete shell shall be as follows :

1. The concrete shell shall be designed for loads and load combinations as specified. Working stress method shall be used for design of shell. The modular ratio shall be calculated as per Annexure – B of IS – 456.

2. The concrete shell shall support all platforms as well as corbels, which in turn supports the brick flue.

3. The permissible stress in concrete and reinforcement shall be limited to as specified in clause 8 of IS 4998 (Part 2) and as per Cl. No. 10.02.00 of this section, whichever is critical.

4. The maximum deflection at the top of the chimney for both static and dynamic cases shall not be more than H/500 where `H' is the total height of the windshield above top of the foundation.

5. The static modulus of elasticity of concrete for various concrete grades shall be taken as specified in IS: 456.

6. The dynamic modulus of elasticity of concrete for various concrete grades shall be taken as lower values in the range of values specified in IS : 4998 (Part-I) – 1992.

7. Reinforcement in the shell shall be provided as per IS: 4998 (Part-2). However, the maximum spacing or reinforcement shall not be more than 250 mm both ways in the shell and 300 mm for foundation raft.

   Minimum 0.12% reinforcement shall be provided on either side of stack wind shield.

   While providing vertical reinforcement steel in the shell, the total number of vertical bars shall be continued till such height when alternative bars can be discontinued. However, reduction of bar diameter along the height is permissible. At any section of the shell vertical bars shall be uniformly spaced. Non-uniform spacing of vertical bars is not acceptable.
   One third of the vertical bars can only be lapped at one section.

8. Openings in the shell shall be provided for ductwork, access doors, ash channel and ventilation system etc. The maximum width of opening shall be limited to an angle of not more than $30^0$ subtended at the center of the concrete shell. Openings for ventilation shall be provided along periphery of the wind shield just below top of ash hopper.

   The total plan area of the openings at a particular section shall not be more than 15% of the plan area of concrete shell at that location. The opening size for the purpose of stress calculations shall be taken as 1.1 times the actual width of the opening. The extra reinforcement around opening shall satisfy the requirements given in the following documents and the highest shall be provided.

   a) IS: 4998

b) ACI 307

   c) Reinforced concrete chimney and tower by G.M. Pinfold.

9. Embedment to support the caged ladder shall be provided as required.

10. Caged ladder and elevator enclosures shall be provided keeping provision for a rack and pinion type electrically operated elevator.

11. Minimum thickness of wind-shield at top of base raft level shall be 1000 mm. Minimum thickness of wind-shield at top of chimney shall be 400 mm. However, uniform thickness of shell shall be maintained from top of raft to 3.0 m above top of flue duct entry.

12. Uniform Grade of concrete shall be adopted throughout the height of chimney shell.

- **Insulation**

a) The flue shall be insulated externally. The slag/mineral wool shall be of resin bonded type conforming to IS:8183 in the form of slabs. The material shall have a minimum density of 1.75 kN/cu. m. Maximum coefficient of thermal conductivity shall conform to requirements of IS:3677 at a mean temperature of 150°C.

b) The insulation thickness shall be chosen based on the maximum ambient temperature, insulation surface emissivity of 0.3 and the insulation cold face maximum temperature not exceeding 60 °C. However minimum 100 mm thickness of insulation shall be provided.

c) The insulation shall be tightly secured to the exterior surface of the liner by impaling them on studs fixed to the bricks at 450 mm c/c both horizontally and vertically. The studs shall be plated and be of a minimum thickness of 10 gauge. The studs shall extend a minimum of 25 mm beyond the thickness of insulation and 63 mm. Circular or square metal plate speed washers of standard thickness shall be placed on the extended portion of the studs to hold the impaled insulation material well in place. Further, 20 gauge galvanised wire mesh with a 25 mm hexagonal pattern conforming to IS:3150 shall be wrapped around. Where the wire mesh is jointed, a minimum 150 mm overlap shall be provided. The mesh shall be bound and tied in place with a 16 gauge GI wire at 300 mm centres. Any form of lacing the mesh fibres together shall not be permitted.

d) The diameter of the asbestos rope conforming to grade 1 of IS: 4687 shall be 25 mm.

e) Asbestos mill board shall be 12 mm thick, unless otherwise specified. It shall be plain, dense and have a homogeneous texture, without cracks, flaws or any other manufacturing defects. It shall be laid directly over the concrete after removing all loose materials but without any mortar / plaster bedding.

f) The base for acid resist ing brick lin ing in hopper portion sh all be 75 mm thick vermiculite concrete.

g) No air gap shall be p rovided between insula tion and brick lining. Acco rdingly, openings/cut-o ut in RCC corbels (f or blowing of hot air) and openings in RCC wind shield at top (for venting out of hot air) shall not be provided. The insulatio n shall be packed properly between wind shield and brick lining.

- **Chimney Cap Over Mini shell**

Chimney cap over mini shell shall be as per approved Drawing.

C. **Foundation**

- Please refer provisions of Cl. No. 10.01.00 of this Section.
- The chimney foundation shall b e designed for the most crit ical combination of forces and mo ments, resulting from all possible combinations of the various loading s from the chimney syst em during all stages of constructions.
- Ground wat er table shall be considered at finished grade level for foundation design. The foundation shall be checked for overturning for minimum an d ma ximum vertical loads. Loss of contact of foundation shall also not be allowed in any combination of loads.
- Increase in allowable bearing cap acity of soil under win d/seismic loading/combinations shall not be permitted.
- Base raft o f chimney shall be designed as co ntinuous co nsidering uniform thickness witho ut tapering. Annular raft with hollow inside is not permitted. Thickne ss of raft shall not be le ss than 0 .1 times the diameter of the raft nor 0.4 times th e overhang of raft from the face o f the shell.
- The foundat ion diameter to depth r atio shall be maintained to around 10 and should preferably not exceed 12.

- Minimum 0. 12% reinforcement shall be provided on either face of foundation.

- One intermediate layer of reinforcement in raft shall be provided where the thickness exceeds 2000 mm. Two such intermediate layers of reinforcement shall be provided where the thickness of raft exceeds 4000 mm. Such reinforcement in each direct ion shall not be less than 0.06% of cross-sectional area of raft.

- Concrete pouring sequ ence shall be such tha t no cold jo ints occur. Pouring for raft concrete shall not be more than 3 segments.

- The shrinka ge reinforce ment shall not be le ss than 16mm deformed bars at 600 m centres. In addit ion, vertical chair bars at 600 mm centres shall be provided to support these bars.

D. **Outer Platforms**

Outer platforms, shall be provided as per Directorate of Air Routes & Aerodromes (DARA) Circular for locating Aviation Warning Lights. The platforms shall be equally spaced at a spacing of 40 m (maximum). Top most platform shall be p rovided preferably 2.0 mts below the top of chimney.Additional plat forms for s ampling ports, access doors, clea n out doors etc. shall have to be provided as per requirements.

The minimum clear width of the platforms shall be 1200 mm and a live load of 500 Kg/$m^2$ shall be co nsidered for design in a ddition to th e dead load s and other incidental loads, if any, including construction loads.

Hand railing shall be p rovided all around external platfor ms using 3 2 NB (medium duty) G.I. pipes. The spacing of railing posts shall not be more than 1500 mm center to cen ter. The hei ght of hand railing shall not be le ss than 1250 mm. There shall be three ha ndrails at a bout 450 mm and 850 mm & 1250 mm re spectively above platform le vel. The posts shall be embed ded in RCC curb (150 x 200 high) at outside face of platforms.

150 mm dia GI pipe sha ll be provided to carry ra inwater from all platforms to discharge p oint at ground level. The number of down take pipe sh all be decided as per design.

E. **Doors**

i) **Access Doors**

Two access doors of size 3000 m m x 3500 mm (high) or allowable maximum size and 2000 mm x 210 0 mm (high) shall be provided at ground floor level for truck and personnel access. Electrically operated roll up shutt er of suitable size for truck entry access and h ollow type

pressed steel doors for personal access shall be provided. These doors shall be provided with minimum two coats of acid and alkali resistant paint conforming to IS:158 type-I to give a DFT of 100 microns on inside surface. The outside surface shall be provided with 2 coats of resin based zinc rich primer and two final coats of epoxy paint. The personal access door shall be hinged and provided with positive locking device. The hinges required for connecting the doors with door frames shall be heavy duty butt hinges conforming to IS : 1341 (latest).

16.00.00 **STATUTORY REQUIREMENTS**

The Civil Engineering and buildin g work shall comply with all appropriate statutory requirements including all current Building Control regulations, and with all p lanning or othe r condition s as required by the rele vant local, state, and National authorities.

16.01.00 The contra ctor shall provide fu ll general a rrangement drawing ( Civil, Structural & Architectur al) of a ll b uildings, str uctures and facilities to the Owner for c omment. Th e Contractor shall not proceed with these drawings further without such co mment. Any work carried out by the Contractor using drawings unacceptable by the Owner shall be at the Contractor risk.

16.02.00 The Contractor shall seek and obt ain all nece ssary approvals and detailed planning consents outstanding at the time of placing the contract and shall be responsible for all necessary liaison with such authorities to obtain the same and for the payment of due fees for such approvals.

16.03.00 The Contractor shall obt ain approval from the ap propriate authority regarding the safe means of escape in th e event of f ire or other ha zard before relevant construction work proc eeds. As a minimu m, the Contractor is required to ensure that the work shall comply with all statutory requirements including:

i) Central Go vernment/State Govern ment - for all buildin g control regulation

ii) State factories act - For Safety, he alth & welfare, use of hazardous substance

iii) Central and State Pollution Board - For limits on pollution levels.

iv) Central Water Authority/State Irrigation Department - F or Water obstruction/supply for w ithdrawal of water from local sour ce, locat ion of Intake pump house / Jack well.

v) State Water & Disposal Department - for waste & Foul Water disposal.

vi) Ministry of Environment - for all matters relating to environment.

vii) Ministry of Railway - for all matters for railway line construction.

viii) Tariff Advisory Co mmittee - for regulation concer ning fire safety/means of escape.

ix) Aviation Authorities - for clearance of tall structure like stack etc.

x) State Public Work Department - for regulatio ns on Civil work/road work.

xi) Ministry of Forestry - for deforestation, if any, for site development.

16.04.00 The Contractor shall make due allowance for all necessary negotiation/ administration required and the time needed to obtain these permission and approvals in his programme. Failure to obtain such approvals in a timely manner shall not be a reason for extension of the programme.

17.00.00 **DOCUMENTS TO BE SUBMITTED**

17.01.00 **Design Documents**

A. The Contractor shall be required to prepare a `Basis of Design' for each Elements/Structures of Civil Work expanding on the information given in the specification. The `Basis of Design' shall include the following:

i) A concise description of the form of Structure considered.

ii) A statement of salient assumptions made.

iii) Codes of practice and references used

iv) A description of the design approach

v) Detail Calculations including Computer inputs & results with conclusion.

vi) Design/working drawings showing necessary details

The design and drawings shall be addressed to Owner / consultant appointed by the Owner for scrutiny of the same at least 12 weeks prior to the commencement of the relevant construction activity. The comments of the consultants shall be considered for effecting further revision.

B. The submission shall be in accordance with dates set down in Contractors civil work design and construction programme.

C. The Contractor shall be required to carry out at his own cost, any rectification, alteration or replacement of work progressed within 12 weeks of submission of the design basis and drawings and resulting from engineers comments on the design submission.

D. Acceptance of the Contractor `Basis of Design' calculations or drawings by the Owner shall not relieve the Contractor of any of his obligations to meet all the requirements of the Contract or relieve the Contractor's responsibility for the correctness of design and safety of the structure for the design life of the plant. The Contractor shall make any changes in the design/drawing in the form of DCN without any financial implication, which are necessary to make the work comply with the contract.

E. The Contractor shall prepare detailed calculations for all structure / elements in accordance with cl. no.17.01.00 A. The Contractor shall also make available any additional calculations, other than routine structural calculation, as requested by the Owner during the period of Contract.

F. In addition to Geotechnical investigation report, the Contractor shall arrange and make available any other reports and investigations the Owner deems necessary for safety & stability of plant. The investigations shall be carried out in any standard laboratory of repute and as recommended by the Owner. All laboratory tests shall be carried out in the presence of Owner's engineer.

G. In the event, the Contractor adopts any patented method of design and Construction, not popular or practiced in this country; the Contractor shall sought prior approval of Owner in writing. The Contractor shall forward appropriate literatures, documents, certificates, case histories etc., to establish the viability of the method.

H. The bidder shall submit the tender with a schedule of proposed sub contractors for different construction packages (if necessary), structural consultants, (if any), any hired personnel for expertise, along with their name address, etc. and shall obtain approval of the Owner before fixing up of sub-contractor with required credentials for a particular work.

I. Each calculation document shall include the following

i) Contractor's name

ii) Package identification (if any)

iii) Designer's name/initials

iv) Checker's name/initials

v) Reference No.

vi) Index

vii) Date & Revision No.

viii) Revision identification mark

ix) Detail calculations including computer input data and output.

J. Calculation packages shall preferably be bound at A4 size sheets. All numerical analysis shall be done through computer. The bidder shall have either their own system or have access in other system outside their premises.

The Contra ctor shall b e a bonafide license h older of any software package u sed in this p roject. Any in-house de veloped soft ware ma y also be use d subject to the approval of the Owner through validation with standard computer programme. Any pirat ed & unlawful use of software shall not be permitted. The Contractor shall furnish:

i) Name of Software

ii) Developing Agency

iii) A write-up/overview of the programme. As su pplied by th e copyrighter.

iv) Relevant d ocuments verifying u sers right for using t his software in this country.

K All construction drawings furnishe d by the c ontractor sh all consist of total quantity of concrete (gr ade-wise), reinforcement steel (dia meter-wise ) and structural steel (section-wise).

17.02.00 **Construction Documents**

Based on approved design drawing, detailed drawings for construction will be prepared by the Contractor. For reinforced concrete structures and foundations detailed bar bending schedule s in approved format shall accompany each detaile d drawing. For structur al steel work the Contractor will prepare detailed fabrication drawing along with bill of materials.

Six (6) copi es each of selected or all detailed drawings/ fabrication dr awings as decided by Engineer for all structures /bill of materials need be furnished to Owner/Consultants along with bar bending schedule.

17.03.00 All working & construction drawings shall be drawn by CAD system, and shall be issued in A0/A1 size. The drawing shall include:

i) Name of Project, Owner, Consultant & Contractor.

ii) Title of the Drawing

iii) Drawing No. Issue Date, Revision No.

iv) Statement for Revision

v) Revision Identification Mark

vi) Release Status

vii) Designer/Checker’s/Draughtsman's name/initial

17.04.00 The Contractor, who shall maintain an upto date drawing & document register, shall monitor drawing & document issue. This register shall list all drawings & documents used in the design and construction for civil and structural work. The drawing register shall be a controlled document and shall be kept updated/revised and shall be issued on A4 size sheets.

17.05.00 All drawings, design documents, reports, correspondence pertaining to civil structural work shall be in `English Language'. Documents in any other language shall be translated in English before submitting to Owner.

18.00.00 **LAYOUT**

Before starting the work, the Contractor shall carry out the setting out of foundation and structures and provide levels, with reference to general existing grid and bench mark. If the Contractor uses the grid, bench mark and reference pillar made by other Contractors, he shall co-ordinate with the Contractor and shall satisfy himself of the accuracy of the reference marks. If he is required to set out the foundation afresh, he shall do so independently with reference to the one existing grid and bench mark which has been followed by other agency at the instruction of the Engineer. In case any discrepancy be found, it shall be immediately brought to the notice of the Engineer for any rectification/modification necessary. No complaint shall be entertained at a later stage. The Contractor shall accurately set out the position for holding down bolts and inserts.

If required, in the option of the Engineer, he shall construct and maintain pillars for grid, references and bench marks and maintain them till the completion of the construction. He shall also help the Engineer with instruments, materials and labours for checking the detailed layouts and levels. The Contractor shall be solely responsible for the correctness of the layout and levels, and Engineer's approval shall not be deemed to imply any warranty in carrying out the work correctly. The Tenderers shall take into account the cost of these in quoting their price.

19.00.00 **WORKMANSHIP**

Workmanship shall be of the best quality and all work shall be carried out by skilled workmen except for those which normally require unskilled persons. Welding shall be done by experienced and certified welders in proper sequence using necessary jigs and fixtures. Fabrication shall be done in shops having proper equipment for accurate edge lanning and milling of column shaft ends, base plate surfaces etc., and shaping and dimensioning of anchor bolt assembly, inserts and other misc. items. In addition to the requirement specified above, if the bye- laws of the local Govt., Municipal or other authorities require the employment of licensed or registered workmen for various trades, the Contractor shall arrange to have the work done by such registered or licensed personnel. In case of manufactured materials, the Contractor shall have, with no additional cost to the Owner, the services of the supervisors of the manufacturers to ensure that the work is being done according to the manufacturer’s specifications.

20.00.00 **TEMPORARY WORK**

All scaffoldings, staging, temporary bracing and other necessary temporary work required for proper execution of the Contract shall be provided by the Contractor at his own cost and inclusive of all materials, labour, supervision and other facilities.

The layout and details of such Temporary work shall have the prior approval of the Engineer, but the Contractor shall be responsible for proper strength and safety of the same. All Temporary work shall be so constructed as not to interfere with any permanent work or with the work by other agencies. If it is necessary to remove any of the temporary work at any time to facilitate execution of the work or with the work of other agencies, such removal and re-erection, if required, shall be carried out by the Contractor at the direction of the Engineer without any delay and any extra cost on this account shall be borne by the Contractor.

21.00.00 **INTERFACE WITH STRUCTURES UNDER OTHER'S SCOPE OR EXISTING STRUCTURES**

Modification in layout of foundation/structure during detail engineering stage may be necessary to avoid fouling with those under other's scope or existing structures. Necessary changes on this account will be made without any extra cost to Owner.

22.00.00 **SEQUENCE OF WORK AND PROGRESS REPORT**

The sequence in which the work are to be carried out shall be as approved by the Engineer in accordance with the construction method accepted by the Engineer and to be followed by the Contractor. Contractor shall furnish quality assurance and quality control plan. A programme of work is to be submitted for the Engineer's review and approval and this has to be periodically updated and modified as per actual progress to enable timely completion.

The Contractor shall regularly submit to the Engineer progress reports for periods of working as specified by the Engineer showing upto date progress on all important items of work.

# VOLUME – II

# SECTION-C

# SPECIFIC TECHNICAL REQUIREMENTS FOR ELECTRICAL WORKS

## SPECIFICATION NO. PE-TS----------

**Note : In case of any conflict between section-C & section-D of electrical portion, section-C of electrical portion shall prevail.**

1.00.00 **SCOPE OF WORK**

1.01.00 The scope of supply and services shall include but not be limited to the following for Chimney

a) Equipment and materials as required.

b) All relevant drawings, data and instruction manuals.

c) Erection, testing and commissioning of all electrical equipment and materials supplied under this specification.

d) Obtaining statutory approvals for Aviation warning system from concerned authority.

1.02.00 Chimney shall be provided with but not be limited to the following :

a) Normal and Emergency Power distribution and control system
b) Electrical system for chimney Elevator
c) Aviation Obstruction Lighting system
d) Normal and Emergency Lighting system
e) Cabling and conduit system
f) Earthing system
g) Lightning protection system
h) All accessories, control devices, internal wiring, fittings, supports, hangers, anchor bolts etc. which form part of the equipment or which are necessary.

1.03.00 **Power Supply**

1.03.01 The following power supply arrangement is envisaged for the Chimney

a) One (1) 415 V ± 10%, 3 phase, 4 wire, 50 Hz +3% to -5% (fault level 50 KA) supply to AC Distribution Board for Normal AC Lighting and elevator for Chimney.

b) One (1) 415 V ± 10%, 3 phase, 4 wire, 50 Hz +3% to -5% (fault level 50 KA) supply from emergency source to Lighting board for Emergency lights and Aviation Warning Lights and elevator for Chimney.

Any other, supply voltage, if required for the electrical system, the same shall be arranged by the Contractor through suitable means as necessary without any price implication.

2.00.00 **DISTRIBUTION BOARD**

2.01.00 **AC Distribution Board**
AC distribution board (ACDB) shall be provided for feeding lighting distribution boards, elevator and power receptacles. This AC distribution board shall be located inside the concrete shell of the chimney. The incoming to the ACDB shall be suitable for 415V, 3 phase, 4 wire, 50 Hz supply. 10% spare feeders with minimum one (1) of each type and rating shall be provided.

2.02.00 **Lighting Board**
One (1) lighting board shall be provided for Normal A.C. Lighting and one (1) Lighting board shall be provided for Emergency A.C light and Aviation Warning lighting system for chimney..

Each lighting distribution board shall be provided with an adequately rated dry type, delta/star, lighting transformer with Z not more than 5% and off circuit taps for variation from (-5%) to (+)5% in steps of 2.5% on the primary side. The star point of the secondary side shall be solidly grounded to get the 3 phase, 4 wire supply required for the lighting distribution board. The lighting distribution boards shall have 10% with minimum two (2) spare feeders of each type and rating.

The dry type transformer shall have the following properties :
i) Insulation class of lighting transformer shall be “F”
ii) Temperature rise shall be limited class “B”.
iii) The transformer shall be cast resin type.

2.03.01 AC Distribution Board (ACDB) and Lighting Boards shall be metal enclosed, fabricated from CRCA sheet steel minimum 2 mm thick. AC Distribution Board shall be modular construction, fixed type module, floor-mounted and free-standing type. Each module of ACDB shall be provided with hinged door. Lighting Boards shall be suitable for either wall/column mounting on brackets or floor mounting on channel sills with hinged door on the front.

2.03.02 AC Distribution Board and Lighting Boards shall be dust and vermin-proof, IP- 54 or better.

2..03.03 AC Distribution Board and Lighting Boards shall be so constructed as to permit free access to the terminal connections and easy replacement of parts. Front access doors shall have padlocking arrangements.

2.03.04 AC Distribution Board and Lighting Boards shall have provision of cable entry from bottom as required, with removable gland plates. Necessary double compression type brass cable glands, heavy duty tinned copper cable lugs (for aluminium and copper conductor) shall be furnished by the Contractor.

2.03.05 Two ground pads with M10 G.I. bolts and nuts shall be provided on AC Distribution Board and Lighting Boards for connection to 75mmx10mm G.I. flat.

2.03.06 AC Distribution Board shall be complete with designation and caution notice plates fixed at front and back side and feeder name plate fixed on the front cover. Each Lighting Board shall be complete with designation and caution notice plates fixed on front cover and a circuit directory plate fixed on inside of the front cover. Circuit directory plate shall contain details of the points to be controlled by each circuit including the location of the point controlled, rating of the protective units and loading of the circuit. The plates shall be of anodized aluminium with inscriptions indelibly etched on it.

2.03.07 Bus bar shall be electrolytic grade hard drawn aluminium, colour coded for easy identification and designed for a maximum temperature of 85 Deg.C.

2.03.08 Incoming and outgoing circuits shall be terminated in suitable terminal blocks.

2.03.09 AC Distribution Board shall consist suitable rated MCCB for over load and short circuit protection for incomer, voltmeter with selector switch and suitable PT, C.T. operated ammeter. Outgoing feeder from the AC Distribution Board shall also have MCCB with an over load and short circuit release. It is the Contractor’s responsibility to ensure proper discrimination between outgoing MCCB of AC Distribution Board and downstream MCCB of Lighting Boards.

2.03.10 Each Lighting Board shall have an incoming triple pole MCCB with neutral link

with over load and short circuit release., Lighting transformer and a number of outgoing miniature circuit breakers (MCB), 9 KA rating. The lighting transformer shall be dry type housed in the cubicle.

2.03.11 Access door of AC Distribution Board and Lighting Board shall be interlocked with incoming MCCB such that the door can be opened only when the MCCB is in OFF position. Means shall be provided to defeat this interlock.

2.03.12 MCBs (9 KA rating) in Lighting boards shall be suitable for manual closing and opening and also automatic trip on overload and short circuit.

2.03.13 AC distribution board and lighting boards, after application of primer, shall be finished with electrostatic or powder painting process (thickness not less than 50 microns).

3.00.00 **AVIATION OBSTRUCTION LIGHTING FOR CHIMNEY**

3.01.00 **Illumination System for Chimney**

3.01.01 Aviation Obstruction Lighting System

Aviation obstruction lighting system will conform to requirements of the latest Indian Standard, the International Civil Aviation Organization (ICAO), the instruction issued by the Director General of Civil Aviation – India and the Directorate of Air Routes & Aerodromes' (DARA) Circular. In confirmation to tender specifications and clause no. 6.3.8 of Annex-14 of ICAO, high intensity Type 'A' white flashing XENON lights will be provided. AWLs will be provided at 2 levels at E.L.271.0m (considering the Chimney height to be 275m ) and 185.0m & Medium intensity type 'B' Red Flashing LED at 105.0m in conformation to the clause no. 6.3.19 of Annex-14 of ICAO, which says vertical intervals shall not exceed 105.0m. Three (3) nos. of lights will be provided at each level spaced $120^{o}$ apart, confirming cl.no.6.3.11 & 6.3.22 of Annex-14 of ICAO. AWLs will be installed with the setting angles as specified in 6.3.21 of Annex-14 of ICAO i.e.$2^{o}$ at EL105.0m & $0^{o}$ at other levels. A common flasher with flash frequency of 40 flashes per minute will be provided in aviation control panel, such that all AWLs flashes simultaneously as per cl. 6.3.35 of Annex-14 of ICAO. AWLs at EL 271.0 are provided with 1.0m vertical projections and hence the light beam level is below the steel flue top by 3.0m in confirmation with cl.6.3.12 of Annex-14 of ICAO. Aviation painting is omitted as per cl.no.6.1.4c of Annex-14 of ICAO. All AWLs are distributed over 3 phases such that failure of any one phase would not blank any face of chimney i.e R-Y-B, Y-B-R & B-R-Y arrangement. Aviation control panel is provided with photoelectric switch that operates intensity step changer as under.

| **Ambient** | **North sky illuminance (Lux) Step changer operating range** | **AWL intensity Cd** |
|---|---|---|
| Night to Twilight | 21.5 < >53.6 | From 2000 to 20000 |
| Twilight to Day | 377< >646 | From 20000 to 200,000 |
| Day to Twilight | 377< >646 | From 200,000 to 20000 |
| Twilight to Night | 21.5 < >53.6 | From 20000 to 2000 |

Temporary obstruction lighting will be provided during construction. Obstruction lights will be provided at the uppermost part of the stack or the surrounding scaffolding as construction proceeds upwards. As such level specified to have permanent obstruction lights is passed, that level will be provided with temporary lighting.

3.01.02 **Temporary Obstruction Lights**

The EPC Contractor shall provide at two (2) lights located at diametrically opposite points at the top of the chimney during the period of construction till the permanent obstruction lights are installed and energized, to serve as temporary obstruction lighting.

3.03.00 The illumination system of chimney is governed by DCGA guidelines. In case of any changes in the guidelines in future, the same shall be adhered to.

3.04.00 **Aviation Obstruction Light Fixtures (AOL Fixtures)**

3.04.01 Each AOL fixture shall have 100% standby light i.e. twin type. In case of failure of one light, the standby should be activated automatically with auto changeover facility giving hooter feedback. AOL shall be L.E.D type for low and medium intensity and Xenon type for high intensity lights. The degree of protection shall conform to minimum IP 55 grade protection class. High intensity lights shall have intensity step changers. The control panel for the AOLs shall be mounted near the main distribution board at ground level.

4.00.00 **INTERIOR AND EXTERIOR LIGHTS**

4.01.00 Interior platforms and staircase shall be illuminated by PHILIPS type NDC 21or equivalent industrial well glass luminaries with 150 W HPSV lamp and separate control gear box. The number of fixtures shall be selected based on an illumination level of 70 lux for the staircase and platform. Fixture and control gear shall conform to degree of protection IP55 (min.).
At least two (2) fixtures on each platform level shall be fed from aviation warning lighting board (emergency source). All staircase lights shall also be fed from emergency system.

4.02.00 Necessary junction boxes with MCBs shall be provided on each platform to control the platform and staircase lights.

4.03.00 One (1) 15A, 240V, single phase industrial, weatherproof type, suitable for wall/ column mounting, 3-pin receptacle with suitable interlock shall be provided on each internal and external platforms. At least two 63A, 415V, three phase industrial, weatherproof type, 5-pin receptacles shall be provided at the internal platforms.

4.04.00 **Chimney Elevator Machine Room**
Industrial fluorescent luminaries with 2X28W fluorescent lamps with reflector shall be provided for Elevator machine room. The lux level shall be 100 lux. Four (4) numbers of bulk head luminaries with 100 W GLS lamp and wire guard shall be provided in the elevator pit.

4.05.00 **Other Areas**

Distribution & Lighting Boards area
Industrial well glass luminaries with 150 W HPSV lamp and integral control gear shall be provided in the Distribution & Lighting boards area. The lux level shall be 150 lux.

5.00.00 **CABLES AND CONDUITS**

5.01.00 Power cables shall have stranded aluminium conductor, 1100 V grade XLPE insulated, extruded PVC inner sheath galvanized steel wire armoured, overall extruded PVC sheath.

Control cables shall have stranded annealed tinned copper conductor, 1100V grade PVC insulation, extruded PVC inner sheath, galvanized steel wire armoured, overall extruded PVC sheath. Minimum size of control cable shall be 2.5 sq. mm copper. The minimum sizes of LT cable to be chosen are as below:

AL - 16 sq.mm
CU - 2.5 sq.mm

Flexible trailing cable shall have annealed tinned copper conductor, EPR insulated, reinforced with nylon cord, cores laid up, HDCSP inner sheathed, cotton taped and HDCSP overall sheathed conforming to IS:9968. Power, control and trailing cables shall be FRLS type. Lighting wires shall have stranded copper conductor PVC insulated, 1100 V grade, laid in galvanized GI conduits and shall be of following minimum sizes:

- From Lighting panels to junction boxes : IC, 6 SQ.mm
- From junction boxes to lighting fixtures : IC, 2.5 SQ.mm

(Number of wires per lead as required)

- From Lighting panels to receptacles (15A) : IC, 6 SQ.mm

(A1)

5.02.00 Required number of GI pipe conduit of size not less than 32 mm dia shall be provided. Each conduit riser shall run from the lowest embedded pull box to the highest junction box. The lowest pull box shall be located 450mm above grade in the chimney. Pull boxes shall be installed at every 10m intervals vertically. The conduit risers shall run adjacent to the stairs such that the pull boxes become easily accessible from the stairs.

5.03.00 Each conduit riser shall have one circumferential conduit at each platform level. The circumferential conduit at each level shall be provided with three (3) more junction boxes equally spaced at the locations of the aviation warning lights. Suitable conduits shall also be provided from the junction box to the respective light point. The GI pull boxes and junction boxes shall be of size at least 150mm x 150mm x 100mm, 3mm thick, preferably embedded in the concrete shell.

5.04.00 The conduits shall be electrically connected to all circumferential reinforcing rods which are in turn connected to the down conductors.

5.05.00 Conduit joints and connections shall be made thoroughly watertight and rust proof by application of white lead for embedded portion or red lead for exposed portion.

5.06.00 Conduits shall be hot dip galvanised conforming to relevant IS.

5.07.00 Conduit system shall be electrically bonded to the grounding system.

**6.00.00 GROUNDING**

6.01.00 The grounding installation work shall conform to the requirements of the Indian Electricity Rules and Code of Practice for Earthing (IS: 3043) as amended up-to-date and grounding notes & details. Each piece of electrical equipment/ structure shall be bonded to the grounding system at two (2) points min.

6.02.00 One end of the galvanized mild steel flat shall be connected to the MS round bar riser by electric arc welding and the other end to the equipment by welding / bolting, as necessary. All welded portion shall be painted with bituminous paints against possible corrosion.

6.03.00 The ground conductor sizes for grounding of electrical equipment, lighting fixtures, junction boxes etc. shall be as follows :

i) Distribution Boards, Lighting : 50 mm x 6 mm GI Flat Panels and motors above 90 KW
ii) Motors above 30 KW up to 90 KW : 35 mm x 6 mm GI Flat
iii) Motors above 5 KW up to 30 KW : 25 mm x 3 mm GI Flat
iv) Motors up to 5 KW : 8 SWG GI wire
v) Lighting Fixtures, junction boxes, : 16 SWG G.I. wire conduits, etc.

7.00.00 **CHIMNEY LIGHTNING PROTECTION**
Lightning protection system shall confirm to the requirements of IS: 2309 amended up-to-date

7.01.00 **Air Termination Rod**
The vertical air terminal rods shall be installed at the top of chimney to protect from lightning strokes.
Installation of air terminal at top the chimney for lightning protection shall be 20mm dia lead coated solid copper rod. The projected length of the rod shall be as required to protect the object from lightning stroke.

All the vertical air terminal rods shall be electrically connected together by means of horizontal conductors of size 75 x 10 mm galvanised steel flats. The air terminal rod shall be properly fixed on the top of the chimney to withstand very high wind pressure.

7.02.00 **Circumferential Band**
The circumferential band shall be 75 x 10 mm galvanised steel flat fixed to the circumference of top of chimney at interval not more than 1.0 m. This shall be mounted with suitable anchors at such a height as to be accessible from the top of platform for maintenance. The anchors shall be embedded in concrete wall of the stack.

7.03.00 **Down Conductors**
Minimum four number of 75mm x 10mm GS flat down conductors shall be provided. These shall be not more than 15m apart on the periphery of the stack at the ground level. The down conductor shall be connected to circumferential band at the top portion of the stack and other end connected to the nearest mild steel rod riser from ground electrode. These conductors shall be continuous as far as practicable. Intermediate breaks shall be electrically bonded to form continuous circuit from top to bottom. Lapping of down conductor by bolting is not acceptable. The down conductor shall be clamped along the surface at intervals of 1500mm by GS clamps. The connection between GS flat & GS clamps shall be done by arc welding. At each chimney platform level, a circular band shall be provided which will be made of 75 x 10 mm GS flat and electrically connected to each down conductor.

7.04.00 **Testing Points**
Test joint shall be provided for each down conductor before termination on earth electrode at a height 1.5m from graded level. Test point shall be covered in 150 x 150 x 150 mm GS box. No sharp bends shall be formed in the down conductors and shall be kept as straight as possible.

7.05.00 **Clamps, Anchors Etc.**
All connections, clamps, anchors etc. of the lightning protection system shall be made of GS fittings. All joints or any other form of electrical connections, unless otherwise specified, shall be

clamped or bolted by high pressure contact to form a connection of adequate current carrying capacity and mechanical strength. Soldered connections will not be permitted.

7.06.00 **Vertical and Horizontal Reinforcing Bars**
All reinforcing bars shall be properly bonded and connected to earthing system which shall be separate than lightning protection. The testing point of the down conductors shall be convenient for testing. Testing point shall be phosphor-bronze gunmetal or copper or other suitable.

7.07.00 **Temporary Lightning Protection**
During construction of chimney, temporary lightning protection shall be maintained by connecting the reinforcement bars to two earth electrodes by means of two 75x10mm GS conductors. These temporary protections shall be provided even after the completion of the chimney till such time the permanent protections are installed. To avoid maleffect of highly corrosive atmosphere around the chimney due to flue gas and weather, the exposed conductors, connections, clamps, base plate etc. shall be protected by hot dip galvanizing. All site-welded joints conductors shall be coated with anti-corrosive paints over a coat of primer.

8.00.00 **DRAWINGS, DATA AND MANUALS**

8.01.00 **To be submitted with the Bid**

8.01.01 Typical general arrangement drawing of Chimney showing location of lighting fixtures, lightning protection system, grounding system etc.

8.01.02 Typical general arrangement drawing of A.C. distribution board, lightning board.

8.01.03 Catalogue cuts of various types of lightning fixtures, major components, cables, conduits etc
8.01.04 Type Test Certificate of various equipment

8.02.00 **To be submitted for Approval (A) / Reference (R) and subsequent Distribution**

8.02.01 Dimensional general arrangement drawing of chimney showing disposition of aviation warning lights, interior lights on platforms and stairs, receptacles, A.C. distribution boards, lighting boards including their fixing arrangements (A).

8.02.02 Arrangement drawings for lightning protection and grounding system (A)

8.02.03 Single line drawing of A.C. distribution boards and lighting boards (A)

8.02.04 Cable and Conduit layout (A)

8.02.05 Technical data sheet of all equipment / components (A).

8.02.06 Instruction Manuals and Catalogue cuts of all equipment (R)

The manuals shall clearly indicate the method of installation, check-up and tests to be carried out before commissioning of the equipment.

8.02.07 Any other relevant drawing or data necessary for satisfactory installation, operation and maintenance.

8.03.00 The Contractor may note that the drawings, data and manuals listed are minimum requirement only. The Contractor shall ensure that all other necessary information required to fully describe the equipment / system offered are submitted with his Bid.

# SECTION - C
# SUB SECTION – A6

# STACK ELEVATORS

## 1. SYSTEM DESCRIPTION

1.1.1 The Rack and pinion type stack elevator is required for installation inside multi-flue or outside single flue chimney. The stack Elevator is normally used for the movement of the maintenance personnel and for materials such as refractory bricks, etc. for maintenance of chimney.

## 2. SCOPE OF SUPPLY AND SERVICES

2.1.1 The scope of supply and services covered under the specification are broadly described below:

2.1.2 One No. Rack and Pinion type stack elevator complete with all other accessories and associated steel work.

2.1.3 Drive motor and control panel for Stack elevator

2.1.4 Control Panel

2.1.5 Equipment earthing

2.1.6 All power and control cables, trailing cables

2.1.7 Limit switches

2.1.8 Over speed governor

2.1.9 Alarm push button in the cage connected to battery operated alarm at elevator base.

2.1.10 Reverse phase relay connected to prevent operation of the cab with improper phase rotation or failure in any phase of power supply.

2.1.11 Continuous duty electrical torque motor recoil cable reels or cable trolley or any equivalent arrangement to maintain electrical power service to all electrical components of the elevator for complete travel of stack elevator.

2.1.12 One auxiliary panel shall be provided and mounted on the graded level enclosure equipped with a main ON-OFF selector switch, main contactor, breaker, relays, control transformer and fuses, tone frequency transmitter or equivalent arrangement, , terminal blocks and all other accessories required for normal operation of the elevator.

2.1.13 One main control panel shall be furnished and mounted on top of the cab. Panel shall be in enclosure equipped with necessary equipment like rectifier, battery charger charger, tone frequency receiver, contactors, breakers, control transformer and fuses, thermal overload relays, and all other equipment and accessories required for normal operation of the elevator.

2.1.14 Cab shall be controlled by semi-automatic floor selection control system. Cab shall be furnished with 240 V grounding receptacle, emergency alarm push button with normally open contact, indicating light, limit switches, and all other necessary control devices required to ensure safe and continuous cab operation. One trailing cable shall connect the main control panel to aux. Panel at ground level. Cable shall supply the cab necessary power supply requirements. Cable guides shall be installed at every 6 m intervals to avoid entanglement of this cable. Control signal between the aux. Panel at ground level, the main control panel on the cab and the landings shall be provided with tone frequency receiver or any other equivalent arrangement by trailing control cable.

2.1.15 Each landing assembly shall include a limit switch and push button control station installed and wired to a landing junction box.

2.1.16 All power cable and race way shall be provided and installed by the bidder for interconnection of the main control panel, auxiliary panel and landing junction boxes. Trailing cables shall be as per relevant IS/IEC standard.

2.1.17 Bidder shall provide, install and connect a system equipment ground to owner's chimney grounding system. Equipment grounding system shall electrically connect panels and junction boxes which contain electrical devices, motors and elevator platform and structures. Raceway system shall not be considered as an equipment ground.

2.1.18 All enclosures containing electrical devices shall be provided with 240 V, single phase heaters with adjustable thermostat control.

2.1.19 Cab shall be equipped with a 240 V AC interior light and duplex outlet.

2.1.20 Cable accessories as required to install the cables in bidder's scope shall be provided by the bidders.

2.1.21 Complete erection, testing and commissioning including all erection materials, consumables and other tools and tackles required for erection along with commissioning spares.

2.1.22 All inserts, anchor bolts, sleeves, anchoring steel and any other items required to complete the job satisfactorily shall be in bidder's scope.

2.1.23 First fill of lubricant and consumables shall be in bidder's scope.

2.1.24 Satisfactory running and maintenance of elevator for a continuous period of 30 days including training of owner's operators.

2.1.25 Supply of One complete set of special maintenance tools and tackles shall be in bidder's scope.

2.1.26 Any other equipment or accessories not specified, but required for the satisfactory operation of chimney elevator shall be in bidder's scope.

2.1.27 Recommended spares including instrumentation for 3 years of normal operation of stack elevator. ( List to be furnished by the bidder and for which order shall be placed separately by owner as per their requirements)

## 3. SPECIFIC REQUIREMENTS

3.1 The equipment supplied, erected and commissioned shall meet the technical requirements of respective Section –D and Data Sheet-A.

3.2 Bidder shall note that all QP and Field quality plans shall be subject to purchaser's approval.

3.3 All equipment offered shall have suitable provision of termination and connection of power and control cables inclusive of cable boxes, lugs and glands, etc.

3.4 All the equipment shall be suitable for the power supply fault level and other climatic conditions as indicated in project information.

3.5 The bidder shall guarantee the rating and performance parameters of the system/equipment offered in accordance with specification requirements.

3.6 It is the responsibility of bidder to arrange license for operation of chimney elevator from statutory body of that area before handing over.

3.7 Bidder shall furnish deviation (clause wise) in the deviation schedule. In absence of dully filled deviation list, it will be presumed that offer is exactly in line with the technical specification.

3.8 Bidder shall furnish duly filled data sheet –B alongwith the offer. In absence of same, offer shall be treated as incomplete.

3.9 Bidder shall offer the stack elevator considering prevailing statutory and regulatory requirements of project location.

3.10 Bidder shall indicate degree of protection of various electrical equipment in the offer.

3.11 Makes of all bought out items shall subject to purchaser's approval after award of contract.

3.12 All drawings/documents shall subject to purchaser's approval after award of contract.

## DATA SHEET

| | | | |
|---|---|---|---|
| 1 | Designation<br>Elevator | : | Rack and Pinion type Stack |
| 2 | Type of loading | : | Passenger/goods |
| 3 | Quantity | : | As per project requirement |
| 4 | Carrying Capacity | : | 400 Kg |
| 5 | Pay load | : | 400 Kg minimum. |
| 6 | Operating Speed | : | 40 m/min. |
| 7 | Dimension of lift and lift well/cut out | : | As per IS:3534 |
| 8 | No. of landings | : | Eight (8) nos. including ground.<br><br>(0.0 m, 25.0M, 65m, 105m, 145m, 185m, 225m, and 265m) |
| 9 | Total vertical travel | : | 265m. |
| 10 | Electrical power supply system | : | 415 V, 3 ph, 50 Hz |
| 11 | Other accessories | : | As required |

# TELANGANA STATE POWER GENERATION CORPORATION LIMITED
# [TSGENCO]

**4X270 MW BHADRADRI TPS**

# VOLUME – II B
## CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

## SPECIFICATION NO. PE-TS-411-600-C001

## SECTION - D
## *GENERAL TECHNICAL SPECIFICATION*

## TECHNICAL SPECIFICATIONS FOR RCC CHIMNEY


**Bharat Heavy Electricals Limited**
**Project Engineering Management**
**PPEI Building, Power Sector,**
**Plot No. 25, Sector 16A,**
**Noida (U.P.)-201301**

## 3 TABLE OF CONTENT

# TECHNICAL SPECIFICATION FOR REINFORCED CONCRETE CHIMNEY

## 1.0.0 SCOPE

This specification covers reinforced cement concrete works, including steel flue and insulation work, painting and protective treatment work, and other works associated with construction of RCC twin flue chimney.

## 2.0.0 GENERAL

### 2.1.0 Work to be provided for by the Contractor

Work to be provided by the Contractor, unless specified otherwise, shall include but shall not be limited to the following :

a) Furnish all labour, supervision, services, insurance, material, power, fuel forms, templates, supports, scaffolding, tools, plants, construction equipment, approaches, transportation etc. required for the entire work.

b) Design and prepare working drawings for formworks, scaffoldings, supports, staging hoisting arrangement for men and material etc. and submit them for approval.

c) Prepare and submit for approval, as per approved schedule, detailed drawings for RCC work in shell, platforms at various levels, roof and ground floor and bending schedules for reinforcement bars, showing the positions and details of spacers, chairs, supports, hangers, openings etc.

d) If in scope, prepare detailed fabrication and erection marking drawings for steel flues including flue expansion compensators, steel flue supports and restraint arrangements along with fittings and accessories and submit them for approval.

e) Prepare and submit for approval detailed shop drawings, with list of materials and material specifications for Load Bearing Insulation Blocks and Lateral Restraint Insulation Blocks.

f) Prepare and submit for approval detailed schemes for operations like material handling, placement of concrete erection of steel flues, fixing of insulations, installation, dismantling and maintenance of flue expansion compensator etc. and for items like approaches, services etc.

g) Design and submit for approval mix proportions for concrete to be

adopted on job.

h) Furnish samples and submit for approval the results of tests for various properties of the following materials :
i) Ingredients of concrete, (ii) Concrete,
iii) Acid/Chemical Resistant Tiles, (iv) Castable refractories, (v) Insulation materials, (vi) Paints. (vii) S/S liner.

i) Provide all incidental items not specified or shown on drawings in particulars but reasonably implied or necessary for successful completion of the work in accordance with drawings and specifications.

j) Produce, if directed by the Engineer, a guarantee, in approved proforma, for satisfactory performance, for a specified period, of material manufactured by specialist firms.

2.2.0 **Work by Others**

No work under this specification will be provided for by agency other than the Contractor for this Contract unless specifically mentioned otherwise in the Contract.

2.3.0 **Codes and Standards**

All works under this Specification, unless specified otherwise, shall conform to the latest revisions/replacements of the following Indian Standard Codes, Criteria, Specifications, along with those mentioned therein. In case any particular aspect of work is not covered by Indian Standards, other standard specification, as may be specified by the Engineer, shall be followed. "IS Specification" shall mean Codes, Criteria etc. of ISI.

IS:6 Moderate heat duty fireclay refractories, Group-A.

IS:104 Ready mixed paint, brushing, zinc chrome, priming.

IS:158 Ready mixed paint, brushing, bituminous, black, lead free, acid, alkali, water and heat resisting for general purposes.

IS:195 Specification for fire clay mortar for laying fireclay refractory bricks.

IS:269 Ordinary, and low heat Portland cement.

IS:383 Coarse and fine aggregates from natural sources for concrete.

IS:432 Mild steel and medium tensile steel bars.

IS:456 Code of practice for plain and reinforced concrete.

IS:516 Methods of test for strength of concrete.

| | |
|---|---|
| IS:732 | Code of practice for electrical wiring installations (System Voltage not exceeding 650 Volts). |
| IS:800 | Code of practice for general construction in steel. |
| IS:813 | Scheme of symbols for welding. |
| IS:814 | Covered electrodes for metal arc welding of structural steel. |
| IS:816 | Code of practice for use of metal arc welding for general construction in mild steel. |
| IS:817 | Code of practice for training and testing of metal arc welders. |
| IS:818 | Code of practice for safety and health requirements in electric and gas welding and cutting operations. |
| IS:822 | Code of procedure for inspection of welds. |
| IS:875 | Draft Standard for Code of practice for structural safety of buildings loading standards. |
| IS:1080 | Code of practice for design and construction of simple spread foundations. |
| IS:1139 | Hot rolled mild steel, medium tensile steel and high yield strength steel deformed bars for concrete reinforcements. |
| IS:1161 | Steel tubes for structural purposes. |
| IS:1199 | Methods of sampling and analysis of concrete. |
| IS:1200 | Methods of measurement of building works. |
| IS:1230 | Cast Iron Rainwater pipes and fittings. |
| IS:1239 (Part-I) | Mild steel tubes. |
| IS:1367 | Technical supply conditions for threaded fasteners. |
| IS:1526 | Sizes and shapes for firebricks (230 mm. series). |
| IS:1554 | Cables. |
| IS:1566 | Hard-drawn steel wire fabric for concrete reinforcement. |
| IS:1608 | Methods for tensile testing of steel products. |
| IS:1730 | Dimensions for steel plate, sheet and strip for structural and general engineering purposes. |

| | |
|---|---|
| IS:1731 | Dimensions for steel flats for structural and general engineering purposes. |
| IS:1786 | Cold-twisted steel bars for concrete reinforcement. |
| IS:1791 | Batch type concrete mixers. |
| IS:1893 | Criteria for Earthquake Resistant Design of Structures. |
| IS:1947 | Flood light. |
| IS:1977 | Structural steel (ordinary quality). |
| IS:2062 | Weldable structural steel. |
| IS:2074 | Ready mixed paint, red oxide - zinc chrome priming. |
| IS:2309 | Code of practice for the protection of buildings and allied structures against lightning. |
| IS:2386 (Part-I) | Methods of test for aggregates for concrete. Particle size and shape. |
| IS:2386 (Part-II) | Estimation of deleterious materials and organic impurities. |
| IS:2386 (Part-III) | Specific gravity, density, voids, absorption and bulking. |
| IS:2386 (Part-IV) | Mechanical properties. |
| IS:2386 (Part-V) | Soundness. |
| IS:2386 (Part-VI) | Measuring mortar making properties of fine aggregate. |
| IS:2386 (Part-VII) | Alkali aggregate reactivity. |
| IS:2386 (Part-VIII) | Petrographic examination. |
| IS:2502 | Code of practice for bending and fixing of bars for concrete reinforcement. |
| IS:2505 | Concrete vibrators, immersion type. |
| IS:2506 | Screed board concrete vibrators. |

| | |
|---|---|
| IS:2633 | Methods of testing uniformity of coating on zinc coated articles. |
| IS:2722 | Portable swing weighbatchers for concrete (single and double bucket type). |
| IS:2750 | Steel scaffoldings. |
| IS:2751 | Code of practice for welding of mild steel bars used for reinforced concrete construction. |
| IS:2950 | Code of practice for design and construction of raft foundations. |
| IS:3025 | Methods of sampling and test (Physical and Chemical) for water used in industry. |
| IS:3043 | Code of Earthing. |
| IS:3144 | Methods of Test for Mineral Wool Thermal Insulation Material. |
| IS:3346 | Method for the determination of thermal conductivity of thermal insulation materials (two slab, guarded hot- plate method). |
| IS:3495 (Part-I to IV) | Method of test for clay building bricks. |
| 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:3677 | Unbonded rock and slag wool for thermal insulation. |
| IS:4014 (Part-I&II) | Code of practice for steel tubular scaffolding. |
| IS:4031 | Method of physical tests for hydraulic cement. |
| IS:4457 | Ceramic Unglazed Vitreous acidresistant tiles. |
| IS:4634 | Method for testing performance of batch-type concrete mixers. |
| IS:4687 | Gland packing asbestos. |
| IS:4832 | Chemical Resistant mortars. |
| IS:4860 | Acid-resistant bricks. |
| IS:4990 | Plywood for concrete shuttering work. |

IS:4998 (Part-I) Criteria for design of reinforced concrete chimneys.

IS:5410 Cement paint, colour as required.

IS:5445 Long fluted machine reamers with Morse taper shanks.

IS:5495 Sizes and shapes for firebrick (300 mm. and higher series).

IS:6911 Stainless Steel plate, sheet and strip.

IS:8112 High strength ordinary portland cement.

IS:8183 Bonded Mineral Wool.

IS:9595 Recommendation for Metal Arc Welding of Carbon and Carbon Manganese steels.

CP326 - British Standard - Protection of structures against lightning.

NEPA NO. 78 Code of protection against lightning.

The Indian Electricity Rules.

The requirements of Department of Civil Aviation, Govt. of India.

2.4.0 **Conformity with Drawings and Specifications**

The Contractor shall carry out all the work in strict accordance with the drawings stamped "Released for Construction" and specification issued to him and as per Contractor's detailed drawings approved by the Consulting Engineer. Prior to concreting, the Contractor shall prepare a check list on a set format of all items of work involved, and inform the Engineer well in advance so that the Engineer shall have the opportunity of satisfying himself if the works mentioned in the format are done according to drawings and specification, and he can allow the Contractor in writing to start pouring of concrete. The entire operation of concreting shall be carried on as per specification, to the complete satisfaction of the Engineer. No deviation from the drawings will be allowed unless otherwise directed by the Engineer in writing.

For Load Bearing Thermal Insulation block assembly and lateral restraint insulation block assembly, Contractor shall design sizes of all components of the blocks and details of their connections, supply and fabricate the same in accordance with the approved shop drawings prepared by him.

For steelwork and metal work, the Contractor shall design all connections, inserts for scaffolding, supply and fabricate all steelwork and metal work and furnish all connection materials in accordance with approved shop drawings prepared by him and/or as instructed by the Engineer, keeping in view the maximum utilization of the available sizes and shapes for metal components.

## 2.5.0 Materials to be used

### 2.5.1 General Requirement

All materials, whether to be incorporated in the work or to be used temporarily for the construction, shall conform to the relevant IS specifications unless stated otherwise and shall be of the quality approved by the Engineer.

### 2.5.2 Cement

Ordinary Portland cement of grade 43, as per the requirements laid down in IS:8112, shall be used, until otherwise stated elsewhere in the specification.

### 2.5.3 Coarse Aggregate

Coarse aggregate shall be graded crushed or broken stone from approved sources, free from impurities and shall be screened free of dust and other deleterious matter. It shall conform to IS:383 or IS:515 and shall be washed clean, if necessary. The maximum size of coarse aggregate for stack superstructure shall be 25 mm down graded, unless otherwise stated (vide serial 5(b) of clause 3.03.06). Grading for a particular size shall conform to relevant IS Codes and shall be such as to produce a dense concrete of specified proportion and strength and shall be of consistency that will work readily into position without segregation.

### 2.5.4 Fine Aggregate

Fine aggregate shall be river or pit sand, free from any clay, earth, vegetable matters, salt or other impurities and shall be clean and fit for use, to the satisfaction of the Engineer. Sand acceptable for the work shall normally have a grading falling within the limits of one of the three grades, mentioned in the relevant IS Specifications.

### 2.5.5 Water

The water for both mixing and curing of concrete shall be clean, free from oil, acid, alkali, organic or other deleterious substances. Contractor shall test the water as and when required by the Engineer.

### 2.5.6 Reinforcement

Mild steel or Medium or High Tensile steel deformed bars specified for reinforcement shall conform to the latest relevant IS Specifications and shall be of tested quality under ISI Certification Scheme. The reinforcement shall be free from any oil, foreign material or mill or rust scales.

### 2.5.7 Steel Flue

a) All mild steel material to be used in construction of steel flue shall comply with IS:2062, IS:1239, IS:1367, IS:1608, IS:800 and with other relevant IS Specifications. The ultimate tensile strength of this steel shall not be less than 410 N/Sq.mm.

b) Stainless steel liners shall be fabricated using materials conforming to the requirements of relevant IS Specifications and/or AISI 316L or

BS:1449 Part-2. Grade of Stainless steel shall be equivalent to BS:1449 (Part-2) 316 S.12.

c) Materials to be used for fabrication of Flue expansion compensator shall be suitable for the flue gas tempeature and shall be acid resisting.

The Expansion compensator shall comprise several layers of materials given below in order from the gas side.

i) Two layer of insulation, each consisting of heavy weight texturized glass cloth impregnated with graphite suspension, having an approximate weight of 1.00 Kg/Sq.m

ii) A continuous filament glass cloth coated both sides with a flouro-elastomer having an approximate weight of 1.5 Kg/Sq.m.

iii) Two layers of PTFE (Poly Tetra Flouro-Ethylene) film of minimum thickness 0.15 mm each.

iv) A layer of glass felt of minimum thickness 10 mm and an approximate weight of 1.5 Kg/Sq.M.

### 2.5.8 **Paints**

Paints to be used for shop coat of fabricated steel shall conform to the IS:2074. Paint for treatment of outside face of Chimney with Cement water proof paint shall conform to IS:5410.

### 2.5.9 **Acid Resistant Tiles and Castable Refractories**

Acid resistant tiles to be provided over roof of stack should conform to IS:4457. Matching mortars to be used for tiles. Castable refractories shall be of hydraulic setting, rapid hardening type. It shall have refractory properties similar to Fire bricks conforming to IS:6, Group-A and working temperature shall be upto 1350 Deg.C.

### 2.5.10 **Insulations**

a) **On Exterior Surface of Flues**

The normal flue gas temperature inside the flue shall be 145 Deg.C with momentary rise upto 400 Deg.C (Maximum) occasionally. The insulation material shall be able to withstand this temperature without any deterioration in thermal properties or breakdown. The thermal conductivity of the insulating material shall not exceed 0.06 W/M Deg.C at a mean temperature of 150 Deg.C. The insulation shall also not be affected by any acid condensation from flue gas and shall be free from any impurities which may cause corrosion to the flue material.

For steel flues 65 mm thick semi rigid resin bonded fibrous mineral wool of density not less than 96 Kg/Cu.m as per IS:8183 or resin bonded fibrous crown glass wool (high temperature) of same thickness and density not less than 36 Kg/Cu.m capable of sustaining temperature to the tune of 540 Deg.C without any loss of material

thermal property, may be used. The mineral wool for exposed top portion of flue shall be semi-rigid with minimum density of 200 Kg/Cu.M or the glass wool for exposed top portion of flue shall have minimum density of 75 Kg/Cu.M.

Slag wool insulation shall not be accepted.

The insulation free from shots should be supplied in the form of mat to be fixed with staggered joints on outer surface of the flue with suitably spaced stud by galvanised wire mesh. Insulation on the top portion of flue shall be covered by stainless steel cladding.

b) **At Load Bearing and Side Restraints of Flues**

Load bearing insulation assembly to have (i) a properly mechined mild steel plate with recess at its top for seating PTFE (Poly Tetra Fluoro Ethylene) sheets conforming to BS:5400 (ii) saddle plate (MS) in the middle having stainless steel plate fixed at its bottom surface and lead/elastomeric sheet at top, and (iii) top plate formed of two numbers insulation blocks each made of minimum 50mm thick rigid, non-combustible asbestos fibre reinforced lime-silica board (SINDANYO BLOCKS NATURAL GRADE CS-51) bonded to mild steel plates at top and bottom. For side restraints assembly of insulation blocks of SINDANYO Natural Grade CS-51 and stainless steel plate shall be used. All stainless steel in these assemblies shall conform to AISI-316L and Mild steel to IS-2062. SINDANYO BLOCKS shall be suitable for operation at 320 Deg.C and shall primarily satisfy the following physical prolperties :

i) Minimum compressive stress prior to onset of compression yield of not less than 12 N/Sq.mm.

ii) Minimum shear strength of 30 N/Sq.mm when tested in accordance with BS:3497-1979.

iii) Thermal conductivity shall not exceed 0.67 W/m Deg.C at a mean temperature of 200 Deg.C and its coeff. of linear expansion not to exceed $1.2 \times 10^{-5}$ per Deg.C.

iv) Adhesive used for bonding purposes shall be of material with equivalent high temperature properties as approved by the Engineer. It may be of "Fortafix Fiborclad Adhesive" as manufactured by Fortafix Ltd., England.

## 2.6.0 Storage of Materials

### 2.6.1 General

All materials shall be so stored as to prevent deterioration and intrusion of foreign matter and to ensure the preservation of their quality and characteristics for the work. Any material, which is deteriorated or is damaged or is otherwise considered defective by the Engineer, shall not be used for construction and shall be removed from site immediately, failing which the Engineer shall be at liberty to get the materials removed. The Contractor shall maintain an upto date accounts of receipt, issue and balance of all materials issued by the Owner.

### 2.6.2 Cement

Contractor shall store cement in water-tight and properly designed stores so that the Cement can be kept dry and the stock can be handled in rotation. The doors of stores shall be at least 30 cm. above G.L. Deteriorated cement shall be removed immediately from the site. Not more than ten bags of cement shall be stacked one above the other.

### 2.6.3 Aggregate

Different materials shall be transported, handled and stored separately in such a manner as to prevent damage, deterioration or contamination. Stock piles of fine and coarse aggregates shall be allowed to drain, so that aggregates do not contain too much water.

### 2.6.4 Reinforcement

Reinforcement shall be stored preferably under cover and stacked off ground in size and grade-wise separate stacks for easy identification.

### 2.6.5 Steel, Metal and Fittings

All steel, metal and fittings to be used for fabrication and erection shall be stored sectionwise and lengthwise in separate stacks, off ground, so that they can be handled, inspected, measured and accounted for easily at any time. If required by the Engineer, the materials may have to be stored in a covered shed.

### 2.6.6 Paints

Paints shall be stored under cover, in air-tight containers. Paints supplied in sealed containers shall be used as soon as possible once the container is opened. Left over paints shall be kept in air-tight containers.

### 2.6.7 Steel Flue

Fabricated pieces of steel (flue) liner shall be stored systematically for ease of handling.

### 2.6.8 Insulation Material

All insulation materials like bearing insulation blocks, restraint insulation blocks, glass or mineral wool, asbestos ropes etc. shall be stored in packing boxes, under covered shed, avoiding their coming in contact with objectionable matter.

## 2.7.0 **Quality Control**

Contractor shall establish and maintain quality control for different items or work and materials as may be directed by the Engineer to assure compliance with contract requirement and submit to the Engineer records of the same. The Contractor shall submit all records and test results in original to the Engineer for his approval, if so desired by him.

The quality control operation shall include but shall not be limited to the following items of work :

| | | | |
|---|---|---|---|
| a) | Cement | : | Test to satisfy relevant IS Specifications if supplied by the Contractor. |
| b) | Aggregate | : | Physical, Chemical and Mineralogical qualities, grading, moisture contents and impurities. |
| c) | Water | : | Impurities Test. |
| d) | Reinforcement: | | Material tests or certificates to satisfy relevant IS Specification if supplied by the Contractor. |
| e) | Structural | : | Material tests or certificate to satisfy Steelrelevant IS Specification if supplied by the Contractor. |
| f) | Steel flue | : | Material tests or certificate to satisfy relevant IS Specification if supplied by the Contractor. |
| g) | Stainless | : | Material tests or certificate to satisfy Steel relevant IS Specification if supplied by the Contractor. |
| h) | Acid Resistant | : | Compressive and tensile strength, acid tiles& mortar resistance and water absorption test. |
| i) | Mortar | : | Compressive and tensile strength, adhesion and acid resistance test. |
| j) | Insulation | : | Thermal conductivity, density, heat and acid resistance tests. Bearing capacity will be tested for bearing/restraint insulation blocks. |

## 3.0.0 EXECUTION

### 3.1.0 Concrete

#### 3.1.1 Trial Mix, Grades of Concrete

At least three weeks before commencing any concreting in the work the Contractor shall make trial mixes using samples of coarse aggregates, sand, water and cement, typical of those to be used in the work. A clean dry mixer shall be used for mixing and the first batch shall be discarded.

For guidance in designing the mix, standard tables for maximum allowable water-cement ratio, minimum cement content, maximum proportion of aggregates and limits of consistency may be used by the Contractor. The Contractor's design mix shall fall within limits of the following tables :

i) Strength requirements of concrete : Table-2 of IS:456-2000.

ii) Concrete Mix Proportion : Table-3 of IS:456-2000.

iii) Minimum cement content/Cu.m. of finished concrete shall be as per Table 5 of IS 456-2000.
However, it should be noted that minimum cement content for concrete of chimney shell of grade M30,M35,M40 shall be 400kg, 430 kg and 450 kg respectively.

iv) Limit of consistency : Refer Table in Item 3.1.4 of this specification.

v) Cement/Total Aggregate Ratio : As per the following table.

## MIX PROPORTIONS (BY WEIGHT) EXPECTED TO GIVE DIFFERENT DEGREES OF WORKABILITY WITH DIFFERENT VALUES OF WATER - CEMENT RATIO (FOR GUIDANCE)

### 3.1 CEMENT/TOTAL AGGREGATES RATIOS

| Workability | Water/ Cement Ratio | Ratio by Weight of Cement to Gravel Aggregate | | Ratio by Weight of Cement to Crushed Stone Aggregate | |
|---|---|---|---|---|---|
| | | 20 mm. Size | 38 mm. size | 20 mm. size | 38 mm. size |
| Very Low slump 0-25 mm. | 0.4 | 01:04.8 | 01:05.3 | 01:04.5 | 1:05 |
| | 0.5 | 01:07.2 | 01:07.7 | 01:06.5 | 01:07.4 |
| | 0.6 | 01:09.4 | 1:10 | 01:07.8 | 01:09.6 |
| | 0.7 | 1:10 | 1:12 | 01:08.7 | 01:10.6 |
| Low slump 25-50 mm | 0.4 | 01:03.9 | 01:04.5 | 01:03.5 | 1:04 |
| | 0.5 | 01:05.5 | 01:06.7 | 1:05 | 01:05.5 |
| | 0.6 | 01:06.8 | 01:07.4 | 01:06.3 | 1:07 |
| | 0.7 | 1:08 | 01:08.5 | 01:07.4 | 1:08 |
| Medium slump 50-100mm. | 0.4 | 01:03.5 | 01:03.8 | 01:03.1 | 01:03.6 |
| | 0.5 | 01:04.8 | 01:05.7 | 01:04.2 | 1:05 |
| | 0.6 | 1:06 | 01:07.3 | 01:05.2 | 01:06.2 |
| High slump 100 - 175 mm. | 0.4 | 01:03.2 | 01:03.5 | 01:02.9 | 01:03.3 |
| | 0.5 | 01:04.4 | 01:05.2 | 01:03.9 | 01:04.6 |
| | 0.6 | 01:05.4 | 01:06.7 | 01:04.7 | 01:05.7 |
| | 0.7 | 01:06.2 | 01:07.4 | 01:05.5 | 01:06.5 |

**NOTE-1 :** Notwithstanding anything mentioned above, the cement / Total aggregate ratio is not to be increased beyond 1:9 without specific permission of the Engineer.

It should be noted that such high aggregate cement ratios will be required for concretes of very low slump and high water-cement ratios which may be required to be used in mass concrete work only.

**NOTE-2** : The above figures are for guidance only, the actual cement/ aggregate ratios are to be worked out from the specific gravities of coarse aggregates and sand being used and from trial mixes. For each grade of concrete, a set of eighteen cubes shall be made. Of these not more than six may be made on any day and further, of the six cubes made in one day not more than two cubes may be made from any single batch. Nine of these cubes each representing a different batch of concrete shall be tested at the age of seven days and remaining at twenty eight days. The making of the cubes, their curing, storing, transporting and testing shall be in accordance with the relevant IS Specifications. The test shall be carried out in laboratory approved by the Engineer. If the average strength of the concrete cubes falls below the requirement, the method described above shall be repeated till acceptable results are obtained. The method may have to be repeated whenever there is a

significant change in the quality of any of the ingredients for concrete, at the discretion of the Engineer.

### 3.1.2 Batching of Concrete

For controlled concrete, only weigh batching shall be allowed. All concrete ingredients, except water, shall be batched by weight, using an approved make of weigh batcher. Batching shall be accurate to 1/2 Kg. The batcher shall be tested for accuracy of calibration, first before commencement of work and at least once a fortnight or as directed by the Engineer thereafter. Water shall be batched by weight or by volume measures, as approved by the Engineer.

### 3.1.3 Mixing of Concrete

Materials for concrete shall be emptied in rotation into the mixer. When all the ingredients are in the drum, the drum will rotate for one minute for dry mixing. After that water shall be added in measured quantities in the manner specified. The mixer shall then rotate for at least two minutes, or at least forty revolutions or until there is apparent uniform distribution of the materials and till the mass is uniform in colour. The entire content of the drum shall be discharged before the ingredients for the succeeding batch are fed into the drum. The mixer shall be thoroughly cleaned to the satisfaction of the Engineer, before a different quality of concrete is put through the mixer and also at the end of day's work.

### 3.1.4 Workability of Concrete

The degree of workability necessary to allow the concrete to be well consolidated and to be worked into the corners of formwork and around the reinforcement and embedments, and to give the required surface finish shall depend on the type and nature of structure and shall be based on experience and tests.120 mm to 150 mm, where concrete is pumped, otherwise, 100mm-120mm slump in chimney shell works shall be adopted subject to Engineer's approval unless stated otherwise (vide serial 1(d) of clause no. 3.3.6). The usual limits of consistency for various types of structure are given below:

## LIMITS OF CONSISTENCY

| Degree of Workability | Slump in mm. with Standard Concrete | | Use for which Concrete is suitable |
|---|---|---|---|
| | Min. | Max. | |
| Very Low | 0 | 15 | Large mass concrete work with heavy compaction equipment. |
| Medium | 35 | 65 | Deep and wide RCC structures with congestion of reinforcement and inserts. |
| High | 65 | 100 | Very narrow and deep RCC structures with congestion due to reinforcement and inserts. |

**NOTE**: The above table is for guidance only. Notwithstanding anything mentioned above, the slump to be obtained for work in progress shall be as per direction of the Engineer.

With the permission of the Engineer, for any grade of concrete, if the water has to be increased in special cases, cement shall also be increased proportionately, to keep the ratio of water to cement same, as adopted in trial mix design, for each grade of concrete.

The workability of concrete shall be checked at frequent intervals by slump tests. Alternatively, where facilities exist or if required by the Engineer, the compacting factor test, in accordance with IS:1199, shall be carried out.

### 3.1.5 **Placing and Compaction of Concrete**

Concreting shall proceed in a manner directed by the Engineer, concrete shall be placed in forms as soon as possible but in no case later than twenty minutes, after mixing.

The height of any single lift of concrete, for different structural members, shall be decided by the Engineer. The concrete shall be placed in the forms gently and not dropped from a height which may cause segregation of aggregates. Each layer of concrete shall be compacted fully before the succeeding layer is placed and separate batches shall follow each other so closely that the succeeding layer shall be placed and fully compacted before the layer immediately below has taken an initial set.

The concrete, after placing, shall be consolidated only by power driven vibrators. The vibrators shall be of a make and size, approved by the Engineer. In using the vibrator, the standard practice and the Engineer's directions, shall be followed.

Vibration shall begin as soon as one batch of concrete has been placed and shall continue till the entire section being poured has been thoroughly consolidated.

To secure even and dense surfaces, free from aggregate pockets, vibration shall be supplemented by tamping or rodding by hand in the corners of forms and along the form surfaces while the concrete is plastic, without damaging or endangering the stability of the formwork.

A sufficient number of spare vibrators including petrol vibrators shall be kept readily accessible to the place of deposition of the concrete to assure adequate vibration in case of breakdown of those in use.

### 3.1.6 **Curing of Concrete**

Curing of exposed surface of concrete shall commence immediately after the concrete has set. Exposed sides shall be covered with canvas etc. immediately after stripping of forms, and curing shall be continued for a period of not less than 14 days, reckoned from the date and hour of completion of concreting. All surfaces of the pour shall be kept wet with water at all times after concreting and till the curing period is over. The Contractor shall plan and employ proper equipment and sufficient labour considered adequate by the Engineer under able supervisor for curing.

### 3.1.7 **Construction Joints**

In concreting the chimney shell one full ring lift shall be completed in a day's pour. Before the formwork for the following pour starts the horizontal surface of the Chimney shell shall be chipped, cleaned and washed with water, and when the formwork is complete, the surface shall be cleaned and washed again and covered with 1:2 sand cement slurry before fresh concrete is placed. The horizontal construction joints shall be so arranged and made that they are regular and neat. No vertical joint shall be allowed. No separate payment shall be allowed to the Contractor for forming joints or chipping and cleaning them or cover with slurry prior to concreting. The number of construction joint shall be kept minimum and the spacing should not exceed three (3) meters. The Contractor shall submit to the Engineer, any proposal of providing construction joints to facilitate his work, for the study and approval of the Engineer well in advance.

### 3.1.8 **Ordinary Concrete**

Ordinary concrete like lean concrete shall be of nominal mix as per relevant clauses of IS:456.

## 3.2.0 **Reinforcement**

### 3.2.1 **Bending of Reinforcement**

All bars shall be carefully and accurately bent by the Contractor in accordance with approved Drawings and bar bending schedules. Special care shall be taken to ensure correct lengths of laps. The bars shall not be bent or straightened in any manner that will injure the bars or impair the bond between reinforcement & concrete. Bends and hooks are to be provided as laid down in the IS:2502.

### 3.2.2 **Placing**

All reinforcement shall be placed and maintained in the position shown in the drawings. Contractor shall provide approved type of cover blocks to suit the requirement of the Drawings. Where reinforcement is to be provided on two faces of the shell, the Contractor shall provide adequate number of separators, with the approval of the Engineer. Any additional support to the reinforcing cage, if required at the time of concreting, shall also be provided, to the satisfaction of the Engineer. Lapping of reinforcement as specified in the drawings or as directed by the Engineer, shall be provided. Laps shall be staggered and too many laps shall be avoided. Welded laps shall be provided only when directed or approved by the Engineer.

### 3.2.3 **Fixing of Reinforcement**

18 SWG annealed steel wire shall be used as binding wire. Bar crossing one another and contact laps shall be bound with this wire twisted tight to make the skeleton or network rigid so that the reinforcement is not displaced during placing of concrete.

3.10 **Forms**

**Construction by Slip-form Method**

Slip-form construction shall be for construction of the wind shield. Type of Slip-form proposed should be indicated in the offer with sketches, drawings and construction statement as explained hereinafter. Number, type and capacities of jacks, the control system and achievable rate of progress in mm/hour should also be indicated. The chosen scheme shall be of a past proven design. A certified performance record of the scheme should be submitted with the offer to guarantee workability of the scheme both from execution time and safety point of view.

The Tenderer should furnish a brief but commprehensive statement indicating the planning & programme and method of work to be followed, for the approval of Owner at the time of submitting Tender. This statement shall include the following items:

i) Type and description of Slip-form equipment and its accessories.

ii) Design of scaffolding and staging.

iii) Description of materials including admixtures to be used for construction.

iv) Manpower planning, construction spaces required, standby arrangement.

vi) Rate of Slip-forming.

vii) Proposed workability requirement of concrete and type of cement & admixture to be used.

viii) Quality assurance programme.

ix) Method of Traansportation of material

x) Method of curing and rectification of defects.

xi) Planned interruption, if proposed, and activities during planned interruption. Treatment of construction joint.

xii) Contingency solution for unplanned interruptions.

xiii) Time of completion.

While selecting the Contractor, due consideration will be given to the merit of the above mentioned statement proposed by the Tenderer.

Not withstanding what have been specified in earlier clauses, following guide lines are being presented which should be kept in view by intending Tenderers, while quoting for Slip-form method of construction:

1. Care to be taken to prevent dragging of concrete along with upward movement of the shuttering. For this purpose following steps are advisable:

   a) Shutter plates have to be smooth and should be thoroughly clean. Before fixing them in position all the surfaces which will be coming in contact with concrete to have a coat of epoxy paint.

   b) In areas where concrete thickness is 750 mm or more, rate of pouring should be such that minimum slipping of shuttering is maintained to avoid initial set of concrete before slip form movement.

   c) Mix design should be so done that it will be self- lubricant at the contact face of shutter and concrete and thus reduce friction. Suitable cement of approved manufacturer (conforming to relevant I.S. Specification) may be used for the purpose. An optimum ratio of coarse/fine aggregate should be established to suit the purpose depending on availability of aggregates.

   d) Mix design also should be so done that it has a slump of around 100mm-120mm, at the point where concrete is placed under an ambient temperature of around 40 Deg.C. This will also keep vibration by needle vibrators to required minimum. Slump should not drop down to zero in less than 45 minutes. Suitable retarding agent and plasticizer of approved manufacture may be added in mix to achieve this purpose. These admixtures to be properly identified by preliminary tests both for performance and for compatibility with particular type of cement proposed to be used.

   Additional steps like spraying of water over the shutters and keeping down the temperature of coarse aggregates by continuous spraying of water over those may be resorted to if ambient temperature is more than 40 Deg.C.

2. Care must be taken to prevent twist, which predominantly occur in the initial stages because of low slipping rate, in the horizontal plane of Slip-form assembly. A thorough check on this aspect must be kept at every 15 minutes interval. One person should exclusively be assigned this work together with rectifying any defect.

3. Every endeavour has to be made so as not to occur any tilt in the shutter assembly. To achieve this following steps need be taken:

   a) Performance of jacks has to be closely observed and any defective one needs immediate replacement. Difference in levels of opposite jacks at any instant of time should not exceed 5 mm.

b) Loading on Slip-form truss/yokes has to be fairly equal.

c) Sleeve through which jacking rod passes has to be of sufficient length so that later gets an uniform clearance and does not get any chance to tilt. Sleeve should have a minimum wall thickness of 3.25 mm and should be such that jacking rod gets a maximum clearance of 1 mm to 1.5 mm around.

4. For taper walled chimneys overlapping of shutters which are kept to effect the tapering, needs careful attention otherwise these may be filled with concrete slurry.

5. In designing the mix following aspects should be borne in mind:

a) Cement used should have an initial setting time of not less than 50 minutes and preferably should have a specific surface around 3600 Sq.Cm.per gram.

b) Coarse and fine aggregates should be well graded and rounded aggregates offer better performance in Slip-form technique. These help to keep down water/cement ratio and also offers better lubrication between concrete and shutter surface. 40 mm down size of coarse aggregates should preferably be used unless reinforcement detailing calls for lesser size aggregates.

c) From the point of view of creep, shrinkage as well as initial setting property of concrete, cement content should not preferably be more than 450 Kg. per Cu.M of concrete.

d) Minimum compressive strength (after 4 to 6 hours of mixing) of concrete immediately below the shutter as slipform proceeds should be between 0.1 to 0.2 Newton/ Sq.mm.

e) It is advisable to use cement from a single source during the entire operation of slipform technique since once the system starts, there might not be any time left for conducting trial mixes if the source of procurement of cement changes.

6. Large diameter vibrator needles should not be used for vibrating concrete. Sizes of these needles should preferably be restricted to 25 mm diameter and to 40 mm diameter - only in exceptional cases. At least two nos. standby vibrator units should always be maintained on top of working deck at all time during the entire period of slipform operation.

7. It is preferable to have membrane curing compounds sprayed on fresh surfaces emerging out of shutter panels for ensuring proper curing at great heights.

   In case such spraying is not envisaged then elaborate arrangement has to be made for adequate supply of water both on inside and outside vertical surfaces with spraying arrangement, necessary length of pipelines and pump of adequate head to serve the purpose. It is always advisable to have a stand-by pump for effective utilisation of the system.

8. Rate of slipping should be around 100 mm – 150mm per hour, subjected to a maximum limit of 3.0 m per 24hrs.

9. Exact number and capacity of jacks as well as spacing of yoke frames are to be determined taking into account various loadings including self weight of the system, dead and live loads on working and other platforms, horizontal load on formwork, wind load etc.

   It is desirable that jacking system, based on which the entire slip form system works, should consist of jacks 3 Tonne/ 6 Tonne capacity and a hydraulic pump with necessary pipe connections.

   Spacing of yoke legs should preferably be kept within 2 metres to prevent overloading on jacks and consequent failure resulting in twist of the formwork.

   Jacking rods should be of 25 mm diameter for 3 Tonne Jacks and 32 mm diameter for 6 Tonne Jacks.

10. At least 30% spare jacks and jacking rods should be kept ready during the entire operation. It is obligatory to maintain spare hydraulic pump along with a set of loose pipes in perfect working condition on top of working deck.

11. In sections where thickness is 500 mm or more it is prudent to go in for two nos. of jacks for each slip form yoke.

12. For effective utility of this technique following areas need careful attentions at the very conceptual stage:

    a) Detailed quality assurance programme.

    b) Advance Planning and preparations.

    c) Arrangement for on site supervision and adequate access facilities.

13. Construction methods including description and types of different equipment proposed to be used, structural arrangement and analysis of the system, description and type of different materials, planned interruptions, description and frequency of various checks and tests for Slipform technique as well as for material, method of preparing, transporting and pouring of concrete, solution for probable defects during slipping, sequence of operations during planned interruptions etc. should be prepared beforehand by executing agency and to be approved by Engineer before starting the actual work.

14. Placing and binding of reinforcement is also a very critical item and needs special attention. From practical considerations not more than two or three layers of horizontal steel can be tied at a time and this causes a definite limitation in placement of reinforcement.

    Vertical reinforcements should be kept vertical by providing suitable holders within the slipform system.

15. It is desirable to have a break of at least one day for every two weeks of continuous operation. Such break should be utilised for various maintenance activities, removal of jack rods etc.

16. Numbers and locations of hoists for lifting concrete, reinforcement and other materials have to be planned well in advance. Capacity of hoists should be such as to match with hourly requirement of concrete and reinforcement. If felt necessary one hoist may be exclusively earmarked for transporting concrete.

    For movement of personnel supervising the work a seperate hoist must be arranged for.

17. The system being operative round the clock it is obligatory to have adequate lighting arrangement both on various platform levels as well as on ground below. Arrangement has to be made for facilitating continuous upward movement of the entire system alongwith slipform.

18. Winches for lifting men and material and mixers, if located within unnsafe area around chimney, should be protected by adequate shelter from possible damage.

19. Proper tele-communication system has to be established between the personnel working on top of Chimney and control room below.

20. A small laboratory should be maintained at site for testing different materials like cement, coarse and fine aggregates. A cube testing machine may also be installed at site for getting quick feed back results.

    Apart from using plumb bobs, level and theodolite instruments for survey purpose arrangement should also be kept for lasers.

21. In case of interruption in the course of slipping of formwork following measures should be taken:

    a) Provision of a key and additional reinforcement at the junction of new and old concrete.

    b) Slip form system should be brought up freely to have a minimum overlap of 100 mm or so over previously cast concrete.

    c) Washing of old concrete surface with compressed air and water jet and thereafter pouring a layer of neat cement grout.

    d) Clearing of shuttering panels of loose materials, concrete etc. by compressed air and applying a coat of epoxy paint, if felt necessary by Engineer.

    e) Neatly finishing the interface of old or new concrete as soon as it comes out of shutter panel.

22. It is preferable to suspend the construction work under high wind condition.

23. It is of utmost importance that for effective implementation of this system an Engineer fully conversant with Slip form technique with enough experience in planning and control of formwork should be in overall command of the site and he should be ably supported by well trained mid level supervisory staff, skilled workers and operators, having experience of similar construction in past. It is to be noted that enough manpower (as agreed by owners engineer at site) of above mentioned quality, is always ensured at site for smooth and uninterrupted work of slip form.

24. Operation of slip form method of construction is a continuous one and it demands continuous/intermediate inspection of accuracies in line, level, dimensions and position and immediate rectification of any noticed deviation. All these ask for personnel of high quality having constant vigilance over the construction activity.

25. While all the activities in effective implementation of the work needs utmost care keeping safety of men and material in mind it is obligatory that all activities should be carried out under the guidance of a qualified and trained safety Engineer.

26. For smooth and unhindered supply of concrete, while the slip form is in operation, it is desired that batching plant for concrete of chimney shell be placed in close proximity of chimney shell. However, all the safety measures required for placing batching plant close to shell must be ensured.

    Safety measures as listed below must be adhered to but should not be limited to only these:

a) Safety helmets and belts to be provided to all supervising staff and workers.

b) Safety nets to be provided below both inside and outside platforms as instructed by Engineer.

c) Hand railing and toe guard to be provided around all openings and platforms.

d) Regular maintenance of equipment, checking of hoists, scaffoldings etc.

e) Passenger hoist must have multiple ropes with adequate factor of safety.

f) Emergency lights, coloured lamps to be provided in accordance with relevant Indian Standards and as supplemented in the Specification and to be operative in case of sudden power failure Emergency standby generator must be kept ready during the entire period of slipform method of construction.

g) Emergency vehicles, first aid facilities must be kept ready during the entire period of work.

26. Permissible construction tolerances should be limited to the following:

| | | |
|---|---|---|
| Variation in wall thickness | : | (-) 5 mm, (+) 25 mm |
| Variation from Design Diameter | : | (±) 25 mm or (±) 2.5 mm per 3 m dia. whichever is larger, but in no case more than (±) 5 mm. |
| Out of Plumb in General | : | 1 in 1000 of height subject to a maximum of 200 mm. |

## 3.4.0 **Steel Flues**

### 3.4.1 **General**

Fabrication and erection of Steel Flues shall conform to "Technical Specification for Fabrication and Erection of Structural Steelworks" furnished in this Specification.

### 3.4.2 Fabrication

Plates out of which flues will be fabricated, should be bent to the required shape on an appropriate machine. No smithy process shall be adopted for the purpose. Plates are to be prevented from distorting by more than the tolerances specified during transportation, storage, handling, erection and jointing. All components should be correctly located and brought into correct alignment and level within specified erection tolerances, before adjacent pieces are jointed or secured.

### 3.4.3 Assembly

Each flue would be assembled from its Component "Cans" near to ground level within the wind-shield. Incomplete flue would be hung only from the flue support platform during assembly, and progessively hoisted to enable connection of further cans at its lower end. Upon completion of the initial sectional length, this length will be hoisted and supported in its final position at the flue support floogr as indicated in the drawing. It is envisaged that each flue will be assembled and hoisted in three sectional lengths; site joints between sectional lengthy being located just above a steel floor level.

Joints between individual cans should be flanged and bolted on outside and to have sealed welded joints on inside in accordance with clause 3.3.0 - "Welded Construction" under Technical Specifications" for Fabrication of structural steel work. The Contractor shall submit a drawing showing proposals for erection and indicating locations of all site joints which should be kept to minimum.

### 3.4.4 Flue Expansion Compensator

For installation of Expansion Compensators, the manufacturer's instruction should form the basis of the Contractor's method. This method, in a statement, should be submitted to the Engineer for approval. Once approved it has to be followed throughout the installation sequence. Expansion Compensators should be prevented from distortion during transportation, handling, erection and jointing, by more stringout tolerances than specified by the manufacturer.

### 3.4.5 Tolerances

Permissible tolerances in the fabrication and erection of steel flues are given below :

| | | | |
|---|---|---|---|
| a) | Internal diameter shall not vary by more than | : | ± 12 mm |
| b) | Centre of any section shall not be eccentric from vertical centre line by more than | : | 10 mm in any 15 metre height |

c) Centre of any section at height 'h' is in mm. above GL shall : (h/2500 + 10 )mm, not be vertical centre where line by more than

d) Local deviation from a true circular form should not exceed the shell thickness (Measurement should be made from a segmental circular template having radius of flue shown in drawing and a chord length equal to 0.15 of that radius).

e) Peaking or stepping at welded horizontal seams shall not exceed 4 mm. (Measurement shall be made with a straight edged template long enough to contact the straight shell on either side of the peaked area).

### 3.4.6 **Erection**

Erection of Steel Flues and C.I. Chimney caps shall be done as per requirement of IS:800. The Contractor shall submit to the Engineer a programme of erection for his approval. All plant, equipment, tools, tackle and any other accessories required for the erection shall be provided by the Contractor. Storing and handling of fabricated materials for erection, setting out of members, providing temporary supports, bracing, fasteners, bolts, nuts etc. shall be the responsibility of the Contractor and shall be taken into account in quoting the rate.

## 3.5.0 **Insulation and Protective Treatment**

### 3.5.1 **Acid and Heat Resistant Paint**

Top 15 meters of the outside face of R.C.C. windshield horizontal surface at the top of windshield and inside face from the top of the windshield to the top of roof slab or as specified in the drawing shall receive a protective treatment of three coats of acid and heat resistant black paint. The quality and type of the paint shall have the prior approval of the Engineer. For this, a small area shall be painted and a sample of paint shall be shown to the Engineer.

The surface to be painted shall be prepared and primary coat, if required as per the paint manufacturer's specification and direction of the Engineer, shall be applied. The paint shall conform, unless otherwise stated, to the requirement of IS:158. Necessary samples, test certificates and manufacturer's literature shall be submitted to the Engineer for his approval. The surface to be painted shall be completely dry before the paint is applied and the drying time between consecutive coats shall not be less than 5 hours. The overall combined thickness of paint shall be a minimum of 230 microns.

### 3.5.2 **Cement Paint**

The outside face of the Chimney shell, unless specified otherwise, shall be painted with Cement water proof paint. The quality shall be approved by the Engineer. Necessary samples shall be submitted to the Engineer for his approval. The surface of the shell shall be prepared as per paint manufacturer's specification. In addition, care shall be taken that the surface is free from stain, honey comb and any rough and uneven surface. The joints

between two shuttering and two lifts of shuttering shall be so prepared that any uneveness, if by chance exists, shall be removed. If one coat of paint is not sufficient to give the required finish, the Contractor shall repaint the surface, until the Engineer is satisfied with the workmanship. The paint shall conform, unless otherwise stated, to IS:5410. Necessary samples, test certificates and manufacturer's literature shall be submitted to the Engineer for approval.

### 3.5.3 Insulation and Packing

All insulation material should be of dimension and type, shown in the drawing. Load bearing insulations at supports and side restraints of Steel liners should be an assembly of M.S. Plates, Stainless Steel Plates, PTFE (Poly Tetra Fluoro Ethylene) sheets and or/asbestos fibre reinforced boards (SINDANYO BLOCKS). Insulation to be fixed on outer surface of steel flues should be made of glass or mineral wool.

a) **Load Bearing Insulation Block**

Load bearing assembly should consist of three units and be fabricated according to approved drawings. It would be fabricated from mild steel units with a stainless steel sheet bearing plate and load bearing insulation blocks as indicated in drawing.

The first unit is bolted to the supporting beam. It consists of a M.S. base plate with bolt holes on which a machined M.S. plate is welded. This plate is provided with recess for PTFE sheet (conforming to BS : 5400) to seat, being lubricated with silicon grease.

The second unit also consists of a M.S. plate having adequate size & thickness as shown in drawing. While one surface of the plate is provided with a stainless steel bearing plate the other surface has a thin layer of lead/ elastomeric sheet. The side having stainless steel surface is placed on PTFE surface of First unit.

The third unit consists of two layers of load bearing insulation blocks each having a minimum thickness of 50 mm and factory bonded to top & bottom M.S. plates. These are separated by 100 mm. long load bearing insulation dowels as shown in the drawing. These plates are in turn welded to two additional M.S. plates. Of the two surfaces thus created one shall be welded to bracket assembly while the other should rest on the lead sheet of second unit. Bearing assembly, thus formed, should be levelled by using suitable M.S. shims.

Support arrangement typically consists of flue support shoe (a part of flue), flue support bracket connected to the shoe by precision bolted connection. The bracket in turn is welded to the bearing assembly, which in turn is bolted to available supporting beams.

Support brackets and bearing assembly are welded to locally thickened area of flue. These support the flue on support platform at suitable locations indicated on the drawing.

The arrangement described above should cater for easy and smooth thermal movements of linear element. Suitable restraint brackets and M.S. stop plates need be provided as shown in drawings to prevent excessive movement and thus keeping different units of bearing assembly in proper position.

b) **Insulation Block at Lateral Restraints**

At flue restraint platforms, necessary restraint arrangement with load bearing insulation blocks and stainless steel bearing plates fixed to the insulation blocks should be provided as indicated in drawings.

Restraint and support brackets need be provided for the bottom supported portion of the flue which rests on the support platform provided at the base to cater for bearing and restraint requirements.

c) **Glass or Mineral Wool**

Insulation thickness of 65 mm as is specified in clause 2.05.10 shall be built up using two (2) layers composed of 40mm and 25 mm thick insulation blocks. Thicker layer shall be put as first layer around the flue on its exterior surface.

The insulation on the flue shall be fixed using chicken G.I. wire mesh, G.I. wire ties, insulation retaining studs, washers etc. All joints shall be staggered. The insulation shall be tightly secured to the exterior surface of the flue by impaling on the studs and fixing in place by means of 63mm round or square metal plated speed washers. 20 gauge galvanized wire netting shall be wrapped continuously over the entire exterior of insulation. The wire mesh shall be 25mm hexagonal pattern conforming to IS:1566. All joints in the mesh shall be tapped a minimum of 150 mm tied by 16 gauge soft annealed wire at 300 mm spacings. Lacing at joints shall not be used. The Contractor before application of insulation, shall take prior approval of actual fixing arrangement from the Engineer.

The insulation shall be able to sustain structural vibrations and shall not settle under such conditions during erection, construction & operation. The insulation shall be suitably tied to prevent dislocation under adverse conditions.

The cladding of stainless steel sheet over the insulation shall be well secured using pins, fasteners etc.

d) **Vermiculite Concrete**

Vermiculite concrete shall be made by mixing exfoliated vermiculite, portland cement and water. It shall be of Grade-B, having a density of

210 Kg./Cu.M. The vermiculite aggregate size shall be maximum 6 mm. The mix shall be 1 cement and 8 vermiculite by volume.

### 3.6.0 Acid-Proof/Chemical Resistant Protection to Roof Slab

Acid-Proof/Chemical Resistant tiles bedded on acid proof/chemical resistant mortar shall be provided for the protection of roof slab. The intervening space between the tiles shall also be filled up by chemical resistant/acid-proof epoxy mortar grouts. The mortar shall be used immediately after mixing.

Tiles shall be made of clay, feldsper or quartz and vitrified at a high temperature in ceramic kilns. These should be unglazed, free from deleterious materials and should conform to IS:4457. Iron oxide in the raw materials used, shall not exceed 2 percent. They should show a fine grained, dense and homogenous fracture when broken. They shall be sound, true to shape, flat and free from flaws and other manufacturing defects. Dimensions of the tiles shall be 198.5 x 198.5 x 35 mm. Depth of the groove on the underside shall not be more than 3 mm. Compressive and tensile strengths of the tiles shall not be less than 70 N/Sq.mm and 3.5 N/Sq.mm respectively.

### 3.7.0 Flue Acid Drains and Manholes

Flue acid drainage system, where provided, will comprise of collection sumps, dilution manholes, conveying pipes including connection to main drainage system.

Stainless steel pipes, bends, collection sumps, fixing straps, bolts etc. conforming to the relevant Indian Standards (or in absence of which British Standard BS:3605) shall be used in work. Pipes should be cut and joined as per manufacturer's instructions so as to leave the surface clean and square to the axis of pipe.

Manhole should be constructed as per drawing. However, for general guidance it may be noted that pit of required dimensions should be excavated, lean concrete (1:2:4 mix) of required thickness to be laid, Acid-proof/Chemical resistant brick masonry in 1:4 acid resistant cement mortar of necessary thickness be built and both sides plastered by 12mm thick acid proof plaster (1:3 mix) having waterproof admixtures.

Manholes should be covered by reinforced concrete slab on which a heavy duty (HD) manhole cover with frame having diameter 560mm and total weight 255 Kg (140 Kg for manhole and 115 Kg for cover) is to be fixed. For additional safety another inner cover or other approved methods may be adopted. The manhole cover shall be distinctively coded to indicate the type of drainage involved.

Inside manholes necessary channels and benchings finished smooth by neat cement in cement concrete (1:2:4) and foot rungs made from 20mm round bars at 300mm centres and staggered should be provided. Rungs should project 100mm from wall face and be embedded 200mm inside cement concrete block made in that location of brick work. These foot rests shall be

painted with coal tar in the projected portions and cement slurry in the embedded part. Joint of any pipe with brick work shall be rendered perfectly leak proof.

Pipes and fittings in the connection pipe to the main drainage system shall be vitrified clayware conforming to relevant IS and laid to the line and level indicated in the drawings.

3.8.0 **Roof Drainage**

3.8.1 **General**

Rainwater outlets and down comers to run along inner face of stack wall, shall be made of standard cast iron rainwater pipes conforming to IS:1230. The brackets used to hold the pipes alongside the walls shall be wrought iron clevis type, split ring type or of perforated strap iron as approved by the Engineer. Each vertical pipe shall hang freely on its bracket fixed just below the socket. Suitable spacer blocks are to be kept in between the pipe and wall surface for fixing the pipe. All bends and junctions shall be provided with water tight clean-outs.

3.8.2 Pipe Joints

All joints between pipes, pipes and fittings and manholes shall be gas-tight when above ground and water tight when under ground. Method of pipe cutting and jointing shall be as per instruction of the pipe and fittings manufacturer or as approved by the Engineer. However following guidelines may be followed in absence of any instruction available from the manufacturer.

Socket and Spigot pipes shall be joined by cast lead joints. Spigot of the following pipe should be centred in the socket of the preceding pipe by tightly caulking in sufficient turns of tarred gasket or hemp yarn to have unfilled half the depth of socket. After the gasket or hemp yarn has been caulked tightly, a jointing ring shall be placed round the barrel and tightened against the face of the socket to prevent air lock. Molten lead shall then be placed round the barrel and tightened against the face of the socket. Thereafter molten lead should be poured in to fill the remainder of the socket and caulked with suitable tools tight round the joint to make up for shrinkage of the molten metal on cooling and should be finished 3mm behind the socket face. If any joint is suspected to be damaged it has to be opened out & redone.
Joints in cast iron pipes with special jointing arrangements like "Tyton" joints etc. shall follow the instructions of the manufacturer.

4.0.0 **TESTING AND ACCEPTANCE CRITERIA**

4.1.0 **General**

The Contractor shall carry out all sampling and testing in accordance with the relevant IS Specifications and as supplemented herein, for the following items or any other item as may be required by the Engineer unless otherwise

specified in this specification. The Contractor shall get the specimens tested in laboratory, approved by the Engineer and shall submit to him, the original test results in triplicate, within seven days after the completion of the test. Engineer may present himself while such tests are being carried out.

4.2.0 **Cement**

Representative samples shall be taken as per the relevant IS Specification from each consignment of Cement received from the Purchaser/Manufacturer/Supplier for carrying out the tests for fineness (by hand sieving), setting time, compressive strength and soundness tests, and the Contractor shall carry out the above tests as per relevant Indian Standard. If the cement is supplied by the Contractor the test shall be carried out by him. The Contractor shall carry out any or all the tests on aggregates as may be required by the Engineer, in accordance with IS:2386 Parts-I to VIII. The acceptance criteria of the samples tested shall be in accordance with the requirements of the relevant IS specifications.

4.3.0 **Water**

Sampling and testing of water being used for concrete works shall be carried out as per IS:3550, by the Contractor, at regular intervals and whenever directed by the Engineer. The final acceptance criterion in case of doubt shall be as per IS:3025.

4.4.0 **Concrete**

The Contractor shall take cubes for works test as per requirement laid down in IS:516 regularly from the day's pour. The number of test cubes to be taken shall be as per IS:456. The Engineer may also use his discretion in deciding the rate of cubes to be taken. The acceptance criteria is to meet the requirement of IS:456. If the cube test results indicate that some portions of the work is below the required strength, the Engineer may order demolition of that portion of work which is below strength and ask the Contractor to rebuild, provided a satisfactory method of load testing is not possible. Such testing or demolishing and rebuilding shall be carried out by the Contractor.

4.5.0 **Steel Flue**

All site and shop welded joints shall be inspected and tested in accordance with clause 4.00.00 of Technical specification for Fab. and Erection of structural steel work.

4.6.0 **Insulations**

The insulating materials shall be tested for its stipulated characteristics and properties in accordance with the latest editions of IS:3144 and IS:3346 and/or as directed by the Engineer.

## 5.0.0 INFORMATION TO BE SUBMITTED

### 5.1.0 With Tender

The following technical information are required with the tender:

a) Source and arrangement of processing of aggregates proposed to be adopted.

b) Type of plant and equipment proposed to be used.

c) Names of firms with which association is sought for to execute the special items of work e.g. flue expansion compensator, load bearing insulation blocks etc. in the contract.

d) Types of formwork proposed to be used. All details as per clause no. 3.03.06 to be submitted, if slip form method is proposed to be used.

e) Shop proposed for fabrication of steel (flue) liners. Detailed write-up on procedure of erection of complete liner system including details of equipment proposed for the same.

f) For insulating material tests to be offered for inspection & tests for which test certificates will be submitted. A drawing showing the details of fixing insulation on the flues at bearings, lateral restraints and exterior surface.

g) Proposal for lifting of men and material in constructing the chimney.

### 5.2.0 After Award

The following information and data including samples where necessary, shall be submitted by the Contractor, progressively during the execution of the Contract.

### 5.2.1 Programme of Execution and requirement of Materials

Within 30 days of the award of the Contract, the Contractor will submit a Master Programme for completion of the work giving monthwise requirement of materials, particularly mentioning in details the materials which are to be supplied by the Owner and for the procurement of which the help of the Owner is required as per the terms & conditions of the Contract. In case the Contractor proposes to take on hire any machinery or tools and plants from the Owner, the detailed phased out programme of such hire is also to be submitted.

The master programme may have to be reviewed and updated by the Contractor quarterly or at more frequent intervals as may be directed by the Engineer depending on the exegencies of the work.

Detailed day to day programme of every month is to be submitted by the Contractor before the commencement of the month.

5.2.2 **Samples**

Samples of all materials proposed to be used shall be submitted as directed by the Engineer, in sufficient quantities, for approval. All samples shall be submitted well in advance of starting work at site. Approved samples will be preserved by the Engineer for future reference. The approval of the Engineer shall not, in any way, relieve the Contractor of his responsibility of supplying material of specified quality.

5.2.3 **Design Mix**

Design mix as per details of this specification giving proportions of ingredients, sources of aggregates and cement along with accompanying test results of trial mixes as per relevant IS Specifications shall be submitted to the Engineer, for his approval, before it can be used on the work.
Further, the mix design for concrete of shell to be validated from a third party agency of national repute, as agreed upon by the owner.

5.2.4 **Detail Drawings**

Following items shall be provided by the Contractor which are to be approved by the Owner and Consultant.

a) Detail drawings and designs of form work including scaffolding to be used. If slipform method of construction is adopted, then detail drawings showing all the arrangements for slipform technique including methods for reducing internal diameter and providing required slopes on outer diameter.

b) Detail drawings and bar bending schedules for concrete components.

c) Shop drawings for structural steel and metal work, including inserts etc. The Contractor shall submit his proposal for testing site and shop joints provided in steel members.

d) Detail drawings for templates and temporary supports for embedments.

e) Category wise requirements of MS, tor and structural steel including GI flats of various sizes for procurement.

f) Detailed drawings of steel flues indicating details of joints, supports and restraints including insulation blocks, and details of expansion compensator.

g) Detailed drawing of hoisting arrangement for men and material satisfying statutory regulations laid down for safety purpose.

5.2.5 **Reports**

Following Test Reports shall be furnished by the Contractor :

a) Mill Test Report for cement and reinforcing steel if the materials are supplied by the Contractor.

b) Inspection Report of bought out items.

c) Inspection Report of formwork and reinforcement, insulations etc.

d) Reports of tests of various material and concrete.

e) Radiographic tests on welded joints in steel flues.

d) Any other data or report or test result required by the relevant IS Specifications and if required by the Engineer for satisfactory quality control of the workmanship.

# VOLUME – II B
## CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

## SPECIFICATION NO. PE-TS-411-620-C001

## SECTION - D

## *GENERAL TECHNICAL SPECIFICATION*

## EARTHWORK IN EXCAVATION AND BACKFILLING

**Bharat Heavy Electricals Limited**
**Project Engineering Management**
**PPEI Building, Power Sector,**
**Plot No. 25, Sector 16A,**
**Noida (U.P.)-201301**

## TABLE OF CONTENT

# TECHNICAL SPECIFICATION FOR EARTHWORK IN EXCAVATION AND BACKFILLING

## 1.0.0 SCOPE

This specification covers excavation in all types of soil, soft and decomposed rock not requiring blasting and rocks requiring blasting, shoring, dewatering, filling around foundations and to grade, compaction of fills and approaches, protective fencing, lighting, etc. relevant to structures and locations covered under the scope of this contract.

## 2.0.0 GENERAL

### 2.1.0 Work to be provided for by the Contractor

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

a) Furnish all labour, supervision, services including facilities as required under statutory labour regulations, materials, scaffolds, equipment, tools and plants, transportation, etc. required for the work.

b) Prepare and submit working drawings showing the approaches, slopes, berms, shoring, sumps for dewatering, including drains and outfall for drainage, space for temporary stacking of spoils, disposal area, fencing, etc. and all other details as may be required by the Engineer.

c) To carry out sampling and testing and submit to the Engineer, results of soil compaction tests whenever required by the Engineer to assess the degree of compaction.

d) Construction, maintenance and removal after completion of magazine of proper capacity as well as design for storing of explosives required for blasting work to be carried out under the scope of this tender including procurement of necessary licenses from proper authorities.

### 2.2.0 Work to be provided for by others

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

### 2.3.0 Codes and Standards

All works under this specification, unless specified otherwise, shall conform to the latest revision and/or replacement of the following or any other Indian Standard Specifications and Codes of Practice. In case any particular aspect

of work is not covered specifically by Indian Standard Specification any other standard practice as may be specified by the Engineer shall be followed :-

| | |
|---|---|
| IS:1200 (Part-I) | Method of Measurement of Building and Civil Engineering work; Part - I Earthwork. |
| IS:2720 (Part-II) | Determination of Moisture Content |
| IS:2720 (Part-VII) | Determination of Moisture content / Dry Relation using Light Compaction. |
| IS:2720 (Part-xiv) | Determination of Density Index (Relative Density) of cohesionless soils. |
| IS:2720 (Part-xxix) | Determination of Dry Density , in place, by core cutter method. |
| IS:2720 (Part- xxviii) | Determination of Dry Density of soils, in place, by sand replacement methods. |
| IS:3764 | Safety code for Excavation work. |
| IS:4081 | Blasting and Related Drilling Operations |
| IS:4701 | Earthwork on canals |

2.4.0 **Conformity with Designs**

The Contractor is to carry out 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 instructions.

2.5.0 **Materials to be used**

2.5.1 **General**

All materials required for the work shall be of best commercial variety and approved by the Engineer.

2.5.2 **Borrow Material**

Borrow material required for back-filling shall be excavated from approved locations and levels, and shall consist of material, approved by the Engineer, free from roots, vegetations, 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.

2.6.0 **Quality Control**

The Contractor shall establish and maintain quality control for the various aspects of the work, method, materials and equipment used. The quality control operation shall include but not be limited to the following items of work :

a) Lines, Levels and Grades : i) Periodic surveys

ii) Establishment of markers, boards etc.

b) Back-filling : i) Checking the quality of fill material

ii) Checking moisture content of the backfill

iii) Checking the degree of compaction

2.7.0 **Information regarding site conditions**

Surface and Sub-surface data regarding the nature of soil, rock, sub-soil water etc. shown on drawing or otherwise furnished to the Contractor shall be taken as a guidance only and variation therefrom shall not affect the terms of the contract. The Contractor must satisfy himself regarding the character and volume of all work under this contract and expected surface, sub-surface and / or sub-soil water to be encountered. He must also satisfy himself about the general conditions of site and ascertain the existing and future construction likely to come up during the execution of the contract so that he may evolve a realistic programme of execution.

3.0.0 **EXECUTION**

3.1.0 **Setting Out**

The Contractor will prepare and submit to the Engineer, detailed drawings of the excavation work as proposed to be executed by him showing the dimensions as per drawings and specification adding his Proposals of slopes, shorings, approaches, dewatering sumps, berms, etc. On receiving the approval from the Engineer with modifications and corrections, if necessary, the Contractor will set out the work from the control points furnished by the Engineer and fix permanent points and markers for ease of future checking.

These permanent points and markers will be fixed at intervals prescribed by the Engineer and checked by the Engineer and certified by him after which the Contractor will proceed with the work. Engineer shall be provided with necessary men, material and instructions for such checking. It should be noted that this checking by the Engineer prior to start of the work will in no way absolve the Contractor of his responsibility of carrying out the work to true lines and levels and grades as per drawing and subsequent corrections, if necessary, in case any errors are noticed in the Contractor's work at any stage.

3.2.0 **Initial Levels**

Initial levels of the ground either in a definite grid pattern or as directed by the Engineer will be taken by the Contractor jointly with the Engineer over the original ground prior to starting actual excavation work and after setting out. These initial levels will be used for preparing cross-sections for volume measurement or for cross-checking the depths obtained from tape measurements.

All records of levels, measurements etc. and also any drawing, cross section etc. made therefrom, shall be jointly signed by the authorised representative of the contractor and the Engineer before the commencement of work and they shall form the basis of all payments in future.

3.3.0 **Clearing and Grubbing, etc.**

The area to be excavated or filled shall be cleared out of fences, trees, logs, stumps, bush, vegetation, rubbish, slush, etc. and levelled up. Trees upto 300mm girth shall be uprooted. Trees above 300 mm girth to be cut, shall be approved by the Engineer and then marked. Felling of trees shall include taking out roots upto 600 mm below ground level or 150 mm below formation level whichever is lower. After the tree is cut and roots taken out the pot-holes formed shall be filled with good earth in 250 mm layers and consolidated unless directed by the Engineer otherwise. The trees shall be cut in suitable pieces as instructed by the Engineer.

Before earthwork is started, all the spoils and unserviceable materials and rubbish shall be burnt or removed from the site to approved disposal areas as may be specified. Ash shall be spread or removed. Useful materials, saleable timber, firewood, etc. shall be the property of the Owner and shall be stacked properly at the worksite in a manner as directed by the Engineer.

3.4.0 **Classification**

All earthwork shall be classified under the following categories :

No distinction will be made whether the material is dry or wet.

a) **Ordinary Soil**

This shall comprise vegetable or organic soil, turf, sand, silt, loam, clay, mud, peat, black cotton soil, soft shale or loose moorum, a mixture of these and similar material which yields to the ordinary application of pick and shovel, rake or other ordinary digging implement. Removal of gravel or any other nodular material having diameter in any one direction not exceeding 75 mm occurring in such strata shall be deemed to be covered under this category.

b) **Hard Soil**

This shall include :

i) stiff heavy clay, hard shale, or compact moorum requiring grafting tool or pick or both and shovel, closely applied ;

ii) gravel and cobble stone having maximum diameter in any one direction between 75 and 300 mm ;

iii) soling of roads, paths, etc., and hard core ;

iv) macadam surfaces such as water bound, and bitumen/tar bound;

v) lime concrete, stone masonry in lime mortar and brick work in lime/cement mortar, below ground level ;

vi) soft conglomerate, where the stones may be detached from the matrix with picks ; and

vii) generally any material which requires the close application of picks, or scarifiers to loosen and not affording resistance to digging greater than the hardest of any soil mentioned in (i) and (vi) above.

c) **Soft and Decomposed Rock**

This shall include :

i) limestone, sandstone, laterite, hard conglomerate or other soft or disintegrated rock which may be quarried or split with crowbars ;

ii) unreinforced cement concrete which may be broken up with crowbars or picks and stone masonry in cement mortar below ground level ;

iii) boulders which do not require blasting having maximum diameter in any direction of more than 300 mm, found lying loose on the surface or embedded in river bed, soil, talus, slope wash and terrace material of dissimilar origin ; and

iv) any rock which in dry state may be hard, requiring blasting, but which when wet becomes soft and manageable by means other than blasting.

d) **Hard Rock** (requiring blasting)

This shall include :

i) any rock or cement concrete for the excavation of which the use of mechanical plant or blasting is required ;

ii) reinforced cement concrete (reinforcement cut through but not separated from the concrete) below ground level; and

iii) boulders requiring blasting.

e) Hard Rock (blasting prohibited)

Hard rock requiring blasting as described under (d) but where blasting is prohibited for any reason and excavation has to be carried out by chiselling, wedging or any other agreed method.

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

## 3.5.0 Excavation for Foundations and Trenches

### 3.5.1 General

All excavations shall be done to the minimum dimensions as required for safety and working facility. Prior approval of the Engineer shall be obtained by the Contractor, in each individual case, for the method he proposes to adopt for the excavations including dimension, side slopes, shoring, dewatering, disposal, etc. This approval, however, shall not in any way make the Engineer responsible for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner.

All excavation in open cuts shall be made true to line, slopes and grades shown on the drawing or directed by the Engineer. No material shall project within the dimension of minimum excavation lines marked. Boulders projecting out of the excavated surfaces shall be removed, if in the opinion of the Engineer they are likely to be a hindrance to the workers.

Method of excavation shall be in every case subject to the approval of the Engineer and the Contractor shall ensure the stability and safety of the excavation, adjacent structures, services and works.

The Contractor shall have full responsibility of the stability of the excavation and safety of the workmen. If any slip occurs, the Contractor shall remove all slipped material from the excavated pit.

All loose boulders, semi-detached rocks, not directly in excavation but so close to the area to be excavated as to be liable, in the opinion of the Engineer, to fall or otherwise endanger the workmen, equipment of the work, etc., shall be stripped off and removed away from the areas of excavation. The method used shall be such as not to shatter or render unstable or unsafe the portion which was originally sound and safe. Any materials not requiring removal as contemplated in the work, but which, in the opinion of the Engineer, is later to become loose or unstable shall also be promptly and satisfactorily removed as directed by the Engineer.

Prior to starting the excavation, the ground level at the location shall be checked jointly with the Engineer.

The rough excavation may be carried upto a maximum depth of 150 mm above the final level. The balance shall be excavated with special care. If directed by the Engineer, soft and undesirable spots shall be removed even below the final level. The extra excavation shall be filled up as instructed by the Engineer.

If the excavation is done to a depth greater than that shown on the drawing, or directed by the Engineer, due to the Contractor's fault, the excess depth shall be filled up to the required level (with cement concrete not leaner than 1:4:8 ordinary concrete or richer) as directed by the Engineer in each individual case.

In formation of rock requiring blasting, those overcuts which are unavoidable will be made up by ordinary cement concrete 1:2:4. All excavated materials such as hard rock, boulders, bricks, dismantled concrete blocks, etc. shall be stacked separately as directed by the Engineer and shall be the property of the Owner.

### 3.5.2 Excavation in Ordinary Soil, Hard Soil and Soft and Decomposed Rock

The excavation in ordinary soil, hard soil, soft and decomposed rock will be carried out as per the approved proposal, modified and corrected where necessary by the Engineer. The work will be carried out in a workmanlike manner without endangering the safety of nearby structures/services or works and without causing hindrance to other activities in the area. As the excavation reaches the required dimensions, lines, levels and grades, the work will be checked by the Engineer thoroughly and the balance work will be carried out carefully to avoid any over-excavation. On completion, the work will be finally checked and approved by the Engineer. 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 just before the foundation work of the structure can be started.

### 3.5.3 Excavation in Hard Rock

In case where excavation, both in ordinary soil and hard rock, are involved, the ordinary soil comprising of soft, hard and dense soils (including laterite formations) and rock including weathered rocks, lateritic rocks, etc. which can be excavated without blasting, shall be completely stripped off. Further work in hard rock shall be resumed after clearance from the Engineer.

Personnel deployed for rock excavations shall be protected from all hazards such as loose rock/boulder rolling down and from general slips of excavated surfaces. Where the excavated surface is such that it is not stable against sliding, necessary supports, props, bracings or bulkheads shall be provided and maintained during the period of construction. Where danger exists of loose rock/boulder falling from the excavated surfaces deeper than 2 metres, steel mesh anchored to the lower edge of

excavation and extending over and above the rock face, adequate to retain the dislodged material shall be provided and maintained.

In case where blasting, though otherwise required, is prohibited for any reasons, the excavation shall be carried out by chiselling, wedging or any other approved method.

### 3.5.4 Blasting

#### 3.5.4.1 General

Storage, handling and use of explosives shall be governed by the current explosive rules laid down by the Central and the State Governments. The Contractor shall ensure that these rules are strictly adhered to. The following instruction, wherever found in variance with the above rules, shall be considered as superseded by the above rules.

No child under the age of 16 and no person who is in a State of intoxication shall be allowed to enter the premises where explosives are stored nor they shall be allowed to handle the explosives.

#### 3.5.4.2 Storage of Explosive

Storage of explosives shall be governed by the current Explosive Rules, Explosives shall be stored in a clean, dry, well ventilated magazine to be specially built for the purpose. Under no circumstances should a magazine be erected within 400 m of the actual work site or any source of fire. A space surrounding the magazine shall be fenced in. The ground inside the fence shall be kept clear and free from trees, bushes etc. The admission to this fenced space shall be by one gate only and no person shall be allowed inside this fence without permission of the Officer-in-charge. The clear space between the fence and the magazine shall not be less than 90m. The mezzanine shall be perfectly well drained.

Two lightning conductors shall be provided to the magazine, one at each end. The lightning conductors shall be tested once in every year.

Fuses and detonators shall be stored in separate magazines. However, detonators can be kept in an annexe adjoining the magazine provided that their number does not exceed 25,000 and that the annexe is so constructed that not less than 60 cm masonry and 100 cm of air space shall intervene between any detonators in such annexe and the interior of the main magazine. Cases containing explosives are not to be opened in a magazine. Explosive in open cases are not to be received into a magazine. Explosives which appear to be in a damaged or dangerous condition are not to be kept in any magazine, but must be removed without delay to a safe distance and destroyed.

Artificial light is not to be allowed in any magazine. No smoking shall be allowed within 100 m of a magazine.

Magazine shoes without nails shall be used while entering the magazine.

The mallets, levers, wedges etc. for opening barrels or cases are to be of wood. Inside a magazine the cases of explosives are to be carried by hand and shall not be rolled or dragged. Explosives which have been issued and returned to the magazine are to be issued first; otherwise those which have been longest in store are to be issued first.

Cases of explosives must be kept clear of the walls and floors for free circulation of air on all sides, special care is to be taken to keep the floor free from grains of powder or portions of explosive matter fallen on the floors due to leakage of cases etc.

The magazine shall not be opened during any duststorm or thunderstorm nor any person shall be allowed in the vicinity of the magazine.

All magazines shall be officially inspected at definite intervals and a record kept of the results of such inspections.

3.5.4.3 **Carriage of Explosives**

Detonators and explosives shall be transported separately to the blast site. Explosives shall be kept dry and away from the direct rays of the sun, naked lights, steam pipes or heated metal and other sources of heat. Before explosives are removed, each cage or package is to be carefully examined to ascertain that it is properly closed and shows no sign of leakage.

No person except the driver shall be allowed to travel on a vehicle conveying explosives. No carriage or vessel shall be used for transporting explosives unless all iron or steel therein with which a package containing any explosive is likely to come in contact is effectually covered with lead, leather, wood, cloth or other suitable material. No lights shall be carried on the vehicle carrying explosives.

No operation connected with the loading, unloading and handling of explosives shall be conducted after sunset.

3.5.4.4 **Use of Explosives**

The Contractor shall appoint an agent who shall personally superintend the firing and all operations connected therewith. The contractor shall satisfy himself that the person so appointed is fully acquainted with the responsibilities imposed on him.

Holes for charging explosives shall be drilled with Pneumatic drills, the drilling pattern being so planned that the rock pieces after blasting will be suitable for handling.

The hole diameter shall be of such a size that cartridges can easily pass down them and undue force is not required during charging. Charging operations shall be carried out by or under the personal supervision of the shotfirer. Wrappings shall never be removed from explosive cartridges. Only

wooden rods shall be used for loading and stemming shotholes. Only one cartridge at a time shall be inserted and gently passed home with the wooden tamping rod.

Only such quantities of explosives as are required for the particular amount of work to be done shall be brought to the works. Should any surplus remain when all the holes have been charged, it shall be carefully removed to a point at least 300 m from the firing point.

The explosives shall be fired by means of an electric detonator placed inside the cartridge. For simultaneous firing of a number of charges the electric detonators shall be connected with the exploder through the shotfiring cable in a simple series circuit. Due precautions shall be taken to keep the firing circuit insulated from the ground, bare wires, rails, pipes or any other path of stray current and to keep the lead wires short circuited until ready to fire. Any kinks in detonator leading wire shall be avoided.

For simultaneous firing of a large number of shotholes, use of cordtex may be done. Cordtex shall be initiated by an electric detonator attached to its side with adhesive tape, connecting wire or string.

All connections shall be made by the authorised shotfirer himself. The shotfiring cable shall not be dragged along the ground to avoid possible damage to the insulation. The shotfiring cable shall be tested for continuity and possible short circuiting before it is used each time.

The shotfirer shall always carry the exploder handle on his person until he is ready to fire shots. The number of shots fired at a time shall not exceed the permissible limits.

Blasting shall only be carried out at certain specified times to be agreed jointly by the contractor and the Engineer.

Before any blasting is carried out, it shall be ensured that all workmen, vehicles and equipment on the site are cleared from an area of minimum 300 metres radius from the firing point, or as required by statutory regulations, at least ten minutes before the time of firing by sounding a warning siren. The area shall be encirled by red flags.

At least five minutes after the blast has been fired in case of electric firing or as stipulated in the regulations the authorised shotfirer shall return to the blast area and inspect carefully the work and satisfy himself that all charged holes have exploded. Cases of misfired unexploded charges shall be exploded by drilling a parallel fresh hole not less than 600 mm from the misfired hole and by exploding a new charge. The authorised shotfirer shall be present during removal of the debris liable to contain unexploded explosives near the misfired hole. The workmen shall not return to the site of firing until at least half an hour after firing.

When blasting is conducted in the neighbourhood of roads, structures, buildings etc. controlled blasting has to be carried out by drilling shallow shotholes and filling the same with light charge of explosives.

Adequate safety precautions as per building bye-laws, safety code, statutory regulations etc. shall be taken during blasting operations.

3.5.5 **Disposal**

The excavated spoils will be disposed of in any or all the following manners :

a) By using it for backfilling straightway.

b) By stacking it temporarily for use in backfilling at a later date during execution of the Contract.

c) i) By either spreading, Or

ii) spreading and compacting at designated filling areas and / or disposal areas.

d) By selecting the useful material and stacking it neatly in areas designated by the Engineer for use in backfilling by some other agency.

3.5.6 **Disposal of Surplus**

All surplus material from excavation shall be carried away from the excavation site to designated disposal area selected by the Engineer.

All good and sound rock excavated from the pits and all assorted materials of dismantled structures shall be the property of the Owner.

3.5.7 **Protection**

The Engineer shall be notified by the Contractor as soon as the excavation is expected to be completed within a day so that it may be inspected by him at the earliest. Immediately after approval of the Engineer, the excavation must be covered up in the shortest possible time. But, in no case the excavation shall be covered up or worked on before approval and measurement by the Engineer. Excavated material shall be placed beyond 1.5 metres from the edge of the pit or trench or half the depth of the pit or trench whichever is more or further away if directed by the Engineer.

Excavation shall not be carried out below the foundation level of structure close by until required precautions have been taken.

Adequate fencing is to be made enclosing the excavation.

The Contractor shall protect all under-ground services exposed by excavation. The Contractor shall also divert all surface drains, etc. affected by the excavation to maintain the working area neat and clean.

3.5.8 **Dealing with Surface Water**

All working areas shall be kept free of surface water as far as reasonably praticable. Works in the vicinity of cut areas shall be controlled to prevent the ingress of surface water.

No works shall commence until surface water streams have been properly intercepted , redirected or otherwise dealt with.

Where works are undertaken in the monsoon period, the Contractor may need to construct temporary drainage systems to drain surface water from working areas.

### 3.5.9 Dewatering

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 rain water and subsoil water accumulated in excavation and keep the trench dewatered until the construction of foundation structure and backfilling are complete in all respects. (except where such dewatering would need installation of well points or deep wells for which separate payment will be made) Sumps made for dewatering must be kept clear of the foundations. 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.

### 3.5.10 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 or 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.

### 3.5.10.1 Close Timbering

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 250 x 40 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 spacings, cross strutted with ballies or as directed by the Engineer. The length of the bally struts shall depend on the width of the trench or pit.

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 shall be taken

into the ground. No portion of the vertical side of the trench or pit shall remain exposed, so that the earth is not liable to slip out.

The withdrawal of the timber shall be done very carefully to prevent the collapse of the pit or 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.

3.5.10.2 **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 500 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.

3.6.0 **Treatment of Slips**

The Contractor will take all precaution to avoid high surcharges and provide proper surface drainage to prevent flow of water over the sides. These precautions along with proper slopes, berms, shoring and control of ground water should cause no slips to occur. If however slips do occur due to causes beyond the control of the Contractor, the same shall be removed by him and payment shall be made to him on appropriate item rate of earthwork. Slips caused due to negligence of the Contractor will be cleared and back-filled later by him.

3.7.0 **Back-filling**

3.7.1 **General**

The material used for backfilling shall consist of material, approved by the Engineer obtained directly from nearby areas where excavation work by the same agency is in progress, 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 vegetations, harmful salts and chemicals, organic materials, etc.

In certain locations, the Engineer may direct sand fillings. The sand should be clean, well graded and be of quality normally acceptable for use in concrete.

3.7.2 **Filling and Compaction in Pits and Trenches around Structures**

As soon as the work in foundations has been accepted and measured, the spaces around the foundation structures in pits and trenches shall be cleared of all debris, brick bats, mortar droppings, etc., and filled with earth in layers not exceeding 250 mm in loose thickness each layer being watered, rammed and properly compacted to achieve a dry density of not less that

90% of proctor's dry density at optimum moisture content as per IS-2720 ( Part-VII) where backfilling with cohesive soil and sandy silt containing high percentage of silt. For back filling with sand having little or no silt, each layer shall be compacted to a relative density of 75% as per IS-2720 part XIV. Earth shall be rammed with approved mechanised compaction machine. Usually, no manual compaction shall be allowed unless specifically permitted by the Engineer. The final surface shall be trimmed and levelled to proper profile as shown in the drawing and as desired by the Engineer.

Since the degree of compaction depends on the moisture content of the soil, a close watch should be kept on it and corrections done to optimise the moisture content.

### 3.7.3 Plinth Filling

The plinth shall be filled with earth in layers not exceeding 250 mm in loose thickness, watered and compacted as stated under clause no. 3.7.2 with approved compaction machine or manually, if specifically permitted by the Engineer. When the filling reaches the finished level, the surface shall be flooded with water for at least 24 hours, allowed to dry and then rammed and compacted, in order to avoid any settlement at a later stage. The finished level of the filling shall be trimmed to the slope intended to be given to the floor.

### 3.7.4 Filling in Trenches for Water Pipes and Drains

Earth used for filling shall be free from salts, organic or other foreign matter. All clods of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not bigger than 150 mm size in any direction, mixed with fine material consisting of disintegrated rock, moorum or earth as available, so as to fill up the voids as far as possible and then the mixture used for filling. The types of bedding & pipe surround material shall be as specified in the drawings .

Filling in trenches for pipes and drains shall be commenced as soon as the joints of pipes and drains have been tested and passed.

Where the trenches are excavated in soil, the filling shall be done with earth on the sides and top of pipes in layers not exceeding 150 mm, watered, rammed and compacted taking care that no damage is caused to the pipe below. Filling of trenches shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur.

In case of excavation of trenches in rock, the filling upto a depth of 300 mm or the diamter of the pipe whichever is more, above the crown of pipe or barrel shall be done with fine material such as earth, moorum, disintegrated rock or ash according to the availability at site. The remaining filling shall be done with rock filling of boulders of size not exceeding 150 mm mixed with fine material as available to fill up the voids, watered, rammed and compacted.

3.7.5 **Filling in Disposal Area**

Surplus material from excavation which is not required for backfilling will be disposed of in designated disposal areas. The spoils shall not be dumped haphazardly but should be spread in layers approximately 250 mm thick when loose and compacted with the help of compacting equipment. In wide areas rollers will be employed and compaction done to the satisfaction of the Engineer at the optimum moisture content which shall be checked and controlled by the Contractor.

In certain cases the Engineer may direct disposal without compaction which can be done by tipping the spoils from a high bench neatly maintaining always a proper level and grade of the bench.

3.8.0 **Approaches and Fencing**

The Contractor should provide and maintain proper approaches for workmen and for inspection. The roads and approaches around the excavated pits should be kept clear at all times so that there is no hindrance to the movement of men, material and equipment of various agencies connected with the Project. Sturdy and elegant fencing is to be provided around the top edge of the excavation as well as the bottom of the fill at the surplus disposal area where dumping from a high bench is in progress.

3.9.0 **Lighting**

Full scale area lighting is to be provided if night work is permitted or directed by the Engineer. If no night work is in progress, red warning lights should be provided at the corners of the excavated pit and the edges of the fill.

4.0.0 **TESTING AND ACCEPTANCE CRITERIA**

4.1.0 **Excavation**

On completion of excavation, the dimensions of the pits will be checked as per the drawings after the pits are completely dewatered the work will be accepted after all undercuts have been set right and all over excavations filled back to required lines, levels and grades by placing ordinary concrete of 1:4:8 proportion and/or richer and/or by compacted earth, as directed by the Engineer. The choice of grade of concrete will be a matter of unfettered discretion of the Engineer. Over excavation of the sides will be made good by the Contractor while carrying out the back-filling. The excavation work will be accepted after the above requirements are fulfilled and all temporary approaches encroaching inside the required dimension of the excavation have been removed.

4.2.0 **Back-filling**

The degree of compaction shall be sufficient to achieve a dry density of not less than 90% of proctor's dry density at optimum moisture content as

per IS-2720 (Part - VII) or a relative density of 75% as per IS-2720 (Part-XIV) as applicable depending on the nature of back filling material as stated in clause no. 3.7.2 of this specification. The work of back-filling will be accepted after the Engineer is satisfied with the degree of compaction achieved.

## 5.0.0 INFORMATION TO BE SUBMITTED

### 5.1.0 With Tender

Details of Equipment proposed to be used for excavation, back-filling and compaction have to be submitted along with the tender.

### 5.2.0 After Award

After award of the Contract the successful tenderer shall submit the following for approval and adoption :

a) The Contractor shall submit a detailed programme of the work as proposed to be executed giving completion dates of excavation of the various foundations and the time required for back-filling and compaction after completing the foundation for structures.

The programme should show how the excavation and back-filling quantities will be balanced, minimising temporary stacking of spoils. It is to be noted that the Engineer even after initial approval of the programme, may instruct to enhance or retard the progress of work during the actual execution, in order to match with the progress of foundations without attracting any claims from the Contractor. The initial programme being submitted by the Contractor should have sufficient flexibility to take care of such reasonable variations.

b) The Contractor shall submit drawings showing details of slopes, shorings, approaches, sump pits, dewatering lines, fencing etc. for approval of the Engineer for adoption.

# VOLUME – II B
## CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

## SPECIFICATION NO. PE-TS-411-620-C001

## SECTION - D

## *GENERAL TECHNICAL SPECIFICATION*

## CEMENT CONCRETE (PLAIN & REINFORCED)

**Bharat Heavy Electricals Limited**
**Project Engineering Management**
**PPEI Building, Power Sector,**
**Plot No. 25, Sector 16A,**
**Noida (U.P.)-201301**

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# TECHNICAL SPECIFICATION FOR CEMENT CONCRETE (PLAIN & REINFORCED)

## 1.0 SCOPE

### 1.1 General

This specification covers all the requirements, described hereinafter for general use of Plain and Reinforced Cement Concrete work in Structures and locations, cast-in-situ or precast, and shall include all incidental items of work not shown or specified but reasonably implied or necessary for the completion of the work.

**1.2** This specification shall also apply to the extent it has been referred to or applicable with the special requirements of structures covered in SCOPE of IS:456.

**1.3** IS:456 shall form a part of this specification and shall be complied with unless permitted otherwise. For any particular aspect not covered by this Code, appropriate IS Code, specifications and/or replacement by any International Code of practice as may be specified by the Engineer shall be followed. All codes and Standards shall conform to its latest revisions. A list of IS codes and Standards is enclosed hereinafter for reference.

## 2.0 GENERAL

### 2.1 Work to be provided for by the Contractor

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

a) 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, transportations, etc. required for the work.

b) Except where it is excluded from the Scope of Contract, Contractor shall prepare progressively and submit for approval detailed drawings and Bar Bending Schedules for reinforcement bars showing the positions and details of spacers, supports, chairs, hangers etc.

c) Design and prepare working drawings of formworks, scaffolds, supports, etc. and submit for approval.

d) Submit for approval shop drawings for various inserts, anchors, anchor bolts, pipe sleeves, embedments, hangers, openings, frames etc.

e) Submit for approval detailed drawings of supports, templates, hangers, etc. required for installation of various embedments like

inserts, anchor bolts, pipe sleeves, frames, joint seals, frames, openings etc.

f) 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.

g) Design and submit for approval concrete mix designs required to be adopted on the job.

h) Furnish samples and submit for approval results of tests of various properties of the following :

i) The various ingredients of concrete

ii) Concrete

iii) Embedments

iv) Joint seals

i) 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.

j) 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 proforma for satisfactory performance for a reasonable period as may be specified, binding both the manufacturers and the Contractor, jointly and severally.

## 2.2 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.

## 2.3 Information to be submitted by the Tenderer

### 2.3.1 With Tender

The following technical information are required with the tender :

a) Source and arrangement of processing of aggregates proposed to be adopted.

b) Type of plant and equipment proposed to be used.

c) Names of firms, if any, with which association is sought for to execute the special items of work in the contract.

d) Types of formwork proposed to be used.

2.3.2 **After Award**

The following information and data including samples where necessary, shall be submitted by the Contractor progressively during the execution of the contract.

a) **Programme of Execution and Requirement of Materials**

The Contractor will submit a Master Programme for completion of the work giving monthwise requirements of materials for the procurement.

This Master Programme may have to be reviewed and updated by the Contractor, quarterly or at more frequent intervals as may be directed by the Engineer depending on the exigencies of the work.

Detailed day to day programme of every month is to be submitted by the Contractor before the end of the previous month.

b) **Samples**

Samples of the following materials and any other materials proposed to be used, shall be submitted as directed by the Engineer, in sufficient quantities for approval. Approved samples will be preserved by the Engineer for future reference. The approval of the Engineer shall not, in any way, relieve the Contractor of his responsibility of supplying materials of specified qualities :

i) Coarse and fine aggregates.

ii) Admixtures.

iii) Plywood for Formwork.

iv) Embedded and anchorage materials as may be desired by the Engineer.

v) Joint sealing strips and other waterproofing materials.

vi) Joint filling compounds.

vii) Foundation quality Rubber Pads.

c) **Design Mix**

Design mix as per Clauses 2.1 (g) & 3.4 of this specification giving proportions of the ingredients, sources of aggregates and cement, along with accompanying test results of trial mixes as per relevant I.S., is to be submitted to the Engineer for his approval before it can be used on the works.

d) **Detail Drawings and Bar Bending Schedules**

Detailed working drawings and Bar Bending Schedules in accordance with Clause 2.1(b) and 3.16.1 of this specification.

e) **Detailed Drawings and Designs of Formworks to be used**

Detailed design data and drawings of standard formworks to be used as per clause 2.1 (c).

f) Detailed Drawings for Templates & Temporary Supports for Embedments

As per Clause 2.1 (e).

g) Mill Test Reports for Cement & Reinforcing Steel

h) **Inspection Reports**

Inspection Reports in respect of Formwork and Reinforcement and any other item of work as may be desired by the Engineer in accordance with Clause 2.4 of this specification.

i) Test Reports

Reports of tests of various materials and concrete as required under Clause 4.0 : SAMPLING & TESTING of this specification.

j) Any other data which may be required as per this specification.

2.4 **Conformity with Design**

The Contractor will prepare check lists in approved proforma which will be called 'Pour Cards'. These Pour Cards will list out all items of work involved. The Contractor will inform the Engineer, sufficiently in advance, whenever any particular pour is ready for concreting. He shall accord all necessary help and assistance to the Engineer for all checking required in the pour. On satisfying himself that all details are in accordance to the drawings and specifications, the Engineer will give written permission on the same 'Pour Card' allowing the Contractor to commence placement of concrete. Details of all instructions issued by the Engineer and the records of compliance by the Contractor, deviations allowed by the Engineer and any other relevant information will be written on accompanying sheets attached to the Pour Cards. These sheets, termed as 'Progress Cards', will be prepared by the Contractor on approved proforma. The Pour Cards along with accompaniments will be

handed over to the Engineer before starting placement of concrete. One of the mix designs developed by the Contractor as per the I.S. Specifications and established to the satisfaction of the Engineer by trial mixes shall be permitted to be used by the Engineer, the choice being dictated by the requirements of designs and workability. The methods of mixing, conveyance, placement, vibration, finishing, curing, protection and testing of concrete will be as approved or directed by the Engineer.

## 2.5 Materials to be used

### 2.5.1 General Requirement

All materials whether to be incorporated in the work or used temporarily for the construction shall conform to the relevant IS Specifications unless stated otherwise and be of best approved quality.

### 2.5.2 Cement

Generally cement shall be 33 grade ordinary Portland Cement conforming to IS-269 . In special cases any of the following type of cement may be permitted or directed to be used with prior approval by the Engineer :

a) 43 Grade ordinary Portland Cement conforming to IS-8112

b) 53 Grade ordinary Portland Cement conforming to IS-12269

c) Rapid hardening Portland Cement conforming to IS-8041

d) Portland slag cement conforming to IS-455

e) Portland Pozzolona Cement (flyash based) Conforming to IS- 1489 (Part -1)

f) Portland pozzolona Cement (calcined clay based) conforming to IS-1489 (Part-2)

g) Hydrophobic Cement conforming to IS-8043

h) Low heat Portland Cement conforming to IS : 12600

i) Sulphate Resisting Portland Cement conforming to IS-12330

### 2.5.3 Aggregates

Aggregates shall be natural or crushed gravel or crushed rock and free from deleterious material. It shall comply with the requirements of IS-383. All fine and coarse aggregate shall be tested for susceptibility to Alkali Silicate reaction in a laboratory approved by the Engineer.

a) **Coarse Aggregate**

Aggregate of sizes ranging between 4.75 mm and 150 mm will be termed as Coarse Aggregate. Only Coarse Aggregate from approved quarries and conforming to IS:383 will be allowed to be used on the works. Aggregates shall be washed to make it free from deleterious materials, if necessary.

The grading of coarse aggregates by seive analysis shall be as per IS:383. If by the analysis the deficiency of a particular grain size is found, which could affect the density of the concrete, the Engineer may ask the contractor to avoid such quantities of aggregate of the particular size or and such quantity of aggregate of any particular size to achieve the required grading as per IS:383.

b) **Fine Aggregate**

Aggregate smaller than 4.75 mm and within the grading limits and other requirements set in IS:383 is termed as Fine Aggregate or Sand. Only Fine Aggregate from approved sources and conforming to the above IS Specification will be allowed to be used on works.

In certain cases there may be two types of sand , one very fine and the other very coarse. In such cases , the two types shall be combined to meet the requirements of a particular zone of IS:383. In all cases , the preferred zone is Zone - II.

In certain cases crushed stone sand may be added to natural sand in order to achieve the required grading. Crushed stone sand alone may be used only with the approval of the Engineer.

2.5.4 **Water**

Water for use in Concrete shall be clear and free from injurious oils, acids, alkalis, organic matter, salt, silts or other impurities. Normally potable water is found to be suitable. Generally, IS:3550 will be followed for routine tests. Acceptance test for water shall be as per IS:3025, and Table-1 of IS:456.

In case of doubt regarding development of strength , the suitability of water for making concrete shall be ascertained by compressive strength and initial setting time tests as per method of tests in accordance with the requirements of IS-516 & IS- 4031 respectively. The PH value of water shall generally be not less than 6.

2.5.5 **Admixture**

Only admixture of approved quality will be used when directed or permitted by the Engineer . The different types of admixtures which may be necessary to satisfy the concrete mix and the design requirement shall be as per the following I.S. Standards :

IS : 2645 - Integral cement water proofing compound

IS : 9103 - Indian standard specification for Admixtures for Concrete or equivalent American Codes (ASTM C494 and ASTM C260 ) or British Codes ( BS 5075 , Part 1 to 3 ) and may be one of the following :

a) Accelerating admixtures :

- Set accelerating admixtures like "Sigunit Powder" or "Sigunit LN10" .

b) Retarding admixtures :

- Modified ligno sulphonate based set retarding concrete admixture like , "Plastiment R".

c) Water reducing admixtures :

- Modified sulphonated melamine formaldehyde based water reducing concrete admixture like, "Sikament" .

d) Air entraining admixtures :

- Modified ligno sulphonate based air entraining concrete admixture like "FLOMO AEP " or surface - active agents like "Sika AER".

e) **Water proofing admixtures**

- Modified ligno-sulphonate based waterproofing admixture like "Plastocrete Super".

However, the Contractor shall furnish following technical information about the admixtures (alongwith the manufacturer's Catalogue) which he is planning to use in different areas within the scope of work for the approval of the Engineer :

i) Type of admixture

ii) Mix proportion & mode of application in concrete/mortar

iii) Manufacturer's specification & necessary quality assurance certificates ( mainly on chloride & suphate content , PH value infra red analysis & solid content. )

2.5.6 **Reinforcement**

Reinforcement shall be as per relevant IS Specification as mentioned in the Contract/Drawing/Instructions. All bars shall be of tested quality.

2.6.0 **Storage of Materials**

2.6.1 **General**

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 has deteriorated or has been damaged or is otherwise considered defective by the Engineer, shall not be used for concrete and shall be removed from site immediately, failing which, the Engineer shall be at liberty to get the materials removed and Storage of materials shall conform to IS:4082.

2.6.2 **Cement**

Sufficient space for storage, with open passages between stacks, shall be arranged by the Contractor to the satisfaction of the Engineer.

Cement shall be stored off the ground in dry, leak proof, well-ventillated ware-houses at the works in such a manner as to prevent deterioration due to moisture or intrusion of foreign matter.

Cement shall be stored in easily countable stacks with consignment identification marks. Consignments shall be used in the order of their receipts at site. Sub-standard or partly set cement shall not be used and shall be removed from the site, with the knowledge of the Engineer, as soon as it is detected.
Different types of cement shall be clearly marked with the Type and different types of cement shall not be intermixed.

2.6.3 **Aggregates**

Aggregates shall be stored on planks or steel plates or on concrete or masonry surface. Each size shall be kept separated with wooden or steel or concrete or masonry bulk-heads or in separate stacks and sufficient care shall be taken to prevent the material at the edges of the stock piles from getting intermixed. Stacks of fine and coarse aggregates shall be kept sufficiently apart with proper arrangement of drainage. The aggregates shall be stored in easily measurable stacks of suitable depths as may be directed by the Engineer.

2.6.4 **Reinforcement**

Reinforcing steel shall be stored consignment-wise and sizewise off the ground and under cover, if desired by the Engineer. It shall be protected from rusting, oil, grease and distortions. If necessary, the reinforcing steel may be coated with cement wash before stacking to prevent scale and rust. The stacks shall be easily measurable. Steel needed for immediate use shall only be removed from storage.

2.7 **Quality Control**

Contractor shall establish and maintain quality control for different items of work and materials as may be directed by the Engineer to assure compliance with contract requirements and maintain and submit to the Engineer records of the same.

The quality control operation shall include but not be limited to the following items of work :

| | | | |
|---|---|---|---|
| a) | Admixture | : | Type, quantity, physical and chemical properties that affect strength, workability and durability of concrete.<br><br>For air entraining admixtures, dosage to be adjusted to maintain air contents within desirable limits |
| b) | Aggregate | : | Physical, chemical and mineralogical qualities. Grading, moisture content and impurities. |
| c) | Water | : | Impurities tests. |
| d) | Cement | : | Tests to satisfy relevant IS Specifications (only association with Owner's tests, if the supply is made by Owner). |
| e) | Formwork | : | Material, shapes, dimensions, lines, elevations, surface finish, adequacy of form, ties, bracing and shoring and coating. |
| f) | Reinforcement | : | Shapes, dimensions, length of plices, clearances, ties and supports. Quality and requirement of welded splices.<br><br>Material tests or certificates to satisfy relevant IS Specification (If Contractor's supply). |
| g) | Grades of concrete | : | Usage and mix design, testing of all properties. |
| h) | Batching & Mixing | : | Types and capacity of plant, concrete mixers and transportation equipment. |
| i) | Joints | : | Locations of joints, water stops and filler materials. Dimension of joints, quality and shape of joint material and splices. |
| j) | Embedded and Anchorage Items | : | Material, shape, location, setting. |

k) Placing : Preparation, rate of pouring, weather limitations, time intervals between mixing and placing and between two successive lifts, covering over dry or wet surfaces, cleaning and preparation of surfaces on which concrete is to be placed, application of mortar/slurry for proper bond, prevention of cold joint, types of chutes or conveyors.

l) Compaction : Number of vibrators, their prime mover, frequency and amplitude of vibration, diameter and weight of vibrators, duration of vibration, hand-spreading, rodding and tamping.

m) Setting of base & Beaming plates : Lines, elevations and bedding mortar.

n) Concrete Finishes : Repairs of surface defects, screening, floating, steel trowelling and brooming, special finishes.

o) Curing : Methods and length of time.

Copies of records and tests for the items noted above, as well as, records of corrective action taken shall be submitted to the Engineer for approval as may be desired.

## 3.0 INSTALLATION

All installation requirements shall be in accordance with IS:456 and as supplemented or modified herein or by other best possible standards where the specific requirements mentioned in this section of the specification do not cover all the aspects to the full satisfaction of the Engineer.

### 3.1 Washing and Screening of Aggregates

Washing and Screening of coarse aggregate shall be carried out to remove fines , dirts or other deleterious materials.

Washing of fine aggregate shall not be allowed, Fine aggregates shall be screened only to remove dirt or other deleterious materials.

However , all washing & screening of aggregates shall be carried out by approved means to ensure compliance with the aggregate specification.

## 3.2 Admixture

All concrete shall be designed for normal rate of setting and hardening at normal temperature. Variations in temperature and humidity under different climatic conditions will affect the rate of setting and hardening, which will, in turn, affect the workability and quality of the concrete.

Admixtures may be permitted to be used in accordance with IS:456 to modify the rate of hardening, to improve workability or as an aid to control concrete quality. The Engineer reserves the right to require laboratory test or use test data, or other satisfactory reference before granting approval. The admixture shall be used strictly in accordance with the manufacturer's directions and/or as directed by the Engineer.

## 3.3 Grades of Concrete

Structural concrete shall be of M30 grade and for other part of the work shall be as shown on the drawing as per grade classification of IS-456. In case of liquid retaining structures, IS:3370 will be followed.

## 3.4 Proportioning and Works Control

### 3.4.1 General

Proportioning of ingredients of concrete shall be made by any of the two following methods as directed by the Engineer.

a) With preliminary tests by designing the concrete mix. Such concrete shall be called 'Design Mix Concrete'.

b) without preliminary tests adopting nominal concrete mix. Such concrete shall be called 'Nominal Mix Concrete'.

As far as possible, design mix concrete shall be used on all concrete works. Nominal mix concrete, in grades permitted in accordance with IS:456, may be used if shown on drawings or approved by the Engineer. In all cases the proportioning of ingredients and works control shall be in accordance with IS:456 and shall be adopted for use after the Engineer is satisfied regarding its adequacy and after obtaining his approval in writing.

### 3.4.2 Mix Design Criteria

Concrete mixes will be designed by the Contractor to achieve the strength, durability and workability necessary for the job, by the most economical use of the various ingredients. In general, the design will keep in view the following considerations :

a) Consistent with the various other requirements of the mix, the quantity of water should be kept at the lowest possible level.

b) The nominal maximum size of coarse aggregate shall be as large as possible within the limits specified.

c) The various fractions of coarse and fine aggregates should be mixed in such a proportion as to produce the best possible combined internal grading giving the densest and most workable mix.

d) Chemical admixtures may be used to modify the rate of hardening, to improve workability (maintaining low water - cement ratio) or as an aid to control concrete quality.

e) The finished concrete should have adequate durability in all conditions, to withstand satisfactorily the weather and other destructive agencies which it is expected to be subjected to in actual service.

The requirement of adequate structural strength is catered for by the choice of proper grade of concrete by the Engineer. The Contractor will strictly abide by the same in his design of concrete mix installation. Notwithstanding anything mentioned in various tables given in IS:456 giving specific values and degrees of workability for different condition of concrete placing, minimum cement content and maximum water-cement ratio for concrete exposed to sulphate attack and for concrete to ensure durability under different condition of exposure, strength requirement for different grades of concrete, proportion for nominal mix concrete, values given in the tables in IS:456, shall be followed.

Various trials shall be given by the contractor with specific cement content on each trial . In some cases, plasticizers and other admixtures may be necessary to achieve the desired results.

## TABLE - I

## STRENGTH REQUIREMENT OF CONCRETE

| | Specified Characteristic Compressive Grade of concrete strength of 15 cm Cubes at 28 days conducted in accordance with IS:516 (All values in N/Sq.mm) |
|---|---|
| M - 10 | 10 |
| M - 15 | 15 |
| M - 20 | 20 |
| M - 25 | 25 |
| M - 30 | 30 |
| M - 35 | 35 |
| M - 40 | 40 |

Note -1: Nominal mix concrete of proportions 1:4:8 or 1:3:6 may be used as lean concrete for simple foundations for masonry walls , below the reinforced concrete foundations and mass filling . These mixes need not be designed.

## TABLE - II

## MIX PROPORTIONS (BY WEIGHT) EXPECTED TO GIVE DIFFERENT DEGREES OF WORKABILITY WITH DIFFERENT VALUES OF WATER - CEMENT RATIO

## (FOR GUIDANCE)

## CEMENT/TOTAL AGGREGATE RATIOS

| WORKABILITY | WATER/CEMENT/RATIO | RATIO BY WEIGHT OF CEMENT OF GRAVEL AGGREGATE | | RATIO BY WEIGHT OF CEMENT OF CRUSHED STONE AGGREGATE | |
|---|---|---|---|---|---|
| | | 20 mm size | 38 mm size | 20 mm size | 38 mm size |
| Very low | 0.4 | 01:04.8 | 01:05.3 | 01:04.5 | 01:05.0 |
| Slump | 0.5 | 01:07.2 | 01:07.7 | 01:06.5 | 01:07.4 |
| 0-25 mm | 0.6 | 01:09.4 | 1:10 | 01:07.8 | 01:09.6 |
| | 0.7 | 1:10 | 1:12 | 01:08.7 | 01:10.6 |
| | | | | | |
| Low | 0.4 | 01:03.9 | 01:04.5 | 01:03.5 | 01:04.0 |
| Slump | 0.5 | 01:05.5 | 01:06.7 | 01:05.0 | 01:05.5 |
| 25-50 mm | 0.6 | 01:06.8 | 01:07.4 | 01:06.3 | 01:07.0 |
| | 0.7 | 01:08.0 | 01:08.5 | 01:07.4 | 01:08.0 |
| | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Medium | 0.4 | 01:03.5 | 01:03.8 | 01:03.1 | 01:03.6 |
| Slump | 0.5 | 01:04.8 | 01:05.7 | 01:04.2 | 01:05.0 |
| 50-100 mm | 0.6 | 01:06.0 | 01:07.3 | 01:05.2 | 01:06.2 |
| | | | | | |
| High | 0.4 | 01:03.2 | 01:03.5 | 01:02.9 | 01:03.3 |
| Slump | 0.5 | 01:04.4 | 01:05.2 | 01:03.9 | 01:04.6 |
| 100-175 mm | 0.6 | 01:05.4 | 01:06.7 | 01:04.7 | 01:05.7 |
| | 0.7 | 01:06.2 | 01:07.4 | 01:05.5 | 01:06.5 |

NOTE : 1 - Notwithstanding anything mentioned above, the cement/Total aggregate ratio is not to be increased beyond 1:9.0 without specific permission of the Engineer.

NOTE : 2 - It should be noted that such high aggregate cement ratios will be required for concretes of very low slump and high water- cement ratios which may be required to be used in mass concrete work only.

NOTE : 3 - The above figures are for guidance only, the actual cement/aggregate ratios are to be worked out from the specific gravities of coarse aggregates and sand being used and from trial mixes.

3.5 **Strength Requirements**

The strength requirements of both design mix and nominal mix concrete where ordinary Portland Cement or Portland slag cement is used, shall be as per Table-2 of IS:456. All other relevant clauses of IS:456 shall also apply.

3.6 **Minimum Cement Content**

The minimum cement content for each grade of concrete shall be as per Table-5 of IS : 456.

3.7 **Water-Cement Ratio**

The choice of water-cement ratio in designing a concrete mix will depend on -

a) The requirement of strength.

b) The requirement of durability.

3.7.1 **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, proportions for different grades of concrete is specified in Table-9 of IS:456 and no tests are necessary. The acceptance test criteria for nominal mix concrete shall be as per IS:456.

3.7.2 **Durability Requirement**

Table-5 of IS:456 gives 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 criterion, the former shall 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 conrete. The contractor may propose lower water cement ratio as mentioned above by addition of a suitable plasticizer / super-plasticizer. 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. It will be preferable to use Melamine based plasticizer.

3.8 **Workability**

The degree of workability necessary to allow the concrete to be well consolidated and to be worked into the corners of formwork and around the reinforcement and embedments and to give the required surface finish shall depend on the type and nature of structure and shall be based on experience and tests. The usual limits of consistency for various types of structures are given below :

**TABLE - III**
**LIMITS OF CONSISTENCY**

| Degree of workability | Slump in mm with Standard Cone as per IS:1199 | | Use for which concrete is suitable. |
|---|---|---|---|
| | Min. | Max. | |
| Very low | 0 | 25 | Large Mass concrete structure with heavy compaction equipment, roads and like. |
| Low | 25 | 50 | Uncongested wide and shallow R.C.C. structures. |
| Medium | 50 | 100 | Deep but wide R.C.C. structures with congestion or reinforcement and inserts. |
| High | 100 | 150 | Very narrow and deep R.C.C. structures with congestion due to reinforcement and inserts. |

(NOTE : Notwithstanding anything mentioned above, the slump to be obtained for work in progress shall be as per direction of the Engineer)

With the permission of the Engineer, for any grade of concrete, if the water has to be increased in special cases, cement shall also be increased proportionately to keep the ratio of water to cement same as adopted in trial mix design for each grade of concrete. The workability of concrete shall be checked at frequent intervals by slump tests. Alternatively where facilities exist or if required by the Engineer, the compacting factor test in accordance with IS:1199.

3.9 **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

Mass concrete in very large structure - 150 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 :

150 mm to 80 mm, 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.

3.10 **Mixing of Concrete**

Concrete shall always be mixed in mechanical mixer unless specifically approved by the Engineer for concrete to be used in unimportant out of the way locations in small quantities. Water shall not normally be charged into the drum of the mixer until all the cement and aggregates constituting the batch are already in the drum and mixed for at least one minute. Mixing of each batch shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency, but in no case shall mixing be done for less than 2 (two) minutes and at least 40 (forty) revolutions after all the materials and water are in the drum. When absorbent aggregates are used or when the mix is very dry, the mixing time shall be extended as may be directed by the Engineer. 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. Such concrete shall be immediately removed from site. Each time the work stops, the mixer shall be thoroughly cleaned & when the next mixing commences, the first batch shall have 10% additional cement to allow for loss in the drum.

Regular checks on mixer efficiency shall be carried out as directed by the Engineer as per IS:4634 on all mixers employed at site. Only those mixers whose efficiencies are within the tolerances specified in IS:1791 will be allowed to be employed.

Ingradients for design mix concrete shall be measured by wieght. For small jobs portable swing weigh Bachers conforming to IS:2722 may be used.

Batching plant conforming to IS:4925 shall be used for large jobs. The accuracy of the measuring equipment shall be within + 2% of the quantity of Cement , water or total aggregates being measured and within + 5% of the quantity of any admixture being used . The batching equipment shall be fitted with an accurate mechanism for weighing separately the cement, fine

aggregate and coarse aggregate. Water may be measured by volume or by weight. All measuring equipment should be maintained in a clean serviceable condition, and their accuracy shall be checked periodically.

Mechanical / electrical control shall be provided on the mixing equipment to ensure the batch cannot be discharged until approved mixing time has elapsed and the entire batch shall be discharged before the mixer is recharged.

Where admixtures are employed, separate containers & measuring devices shall be used.

For minor concreting works, batching by volume according to specific weight may be permitted by the Engineer. In that case the whole bags of cement shall be used and gauge boxes used for measuring aggregates.

When hand mixing is permitted by the Engineer, it shall be carried out on a water-tight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency. In case of hand-mixing, 10% extra cement shall be added to each batch.

## 3.11 Conveying Concrete

Concrete shall be handled and conveyed from the place of mixing to the place of laying as rapidly as practicable by approved means and placed and compacted in the final position before the initial setting of the cement starts. Concrete should be conveyed in such a way as will prevent segregation or loss of any of the ingre- dients. For long distance haulage, agitator cars of approved design will be used. If, inspite of all precautions, segregation does occur during transport, the concrete shall be properly re-mixed before placement. During very hot or cold weather, if directed by the Engineer, concrete shall be transported in deep containers which will reduce the rate of loss of water by evaporation or loss of heat. If necessary, the container may have to be covered and insulated. Conveying equipments for concrete shall be well maintained and thoroughly cleaned before commencement of concrete mixing. Such equipments shall be kept free from set concrete.

## 3.12 Placing and Compacting Concrete

Where specifically covered, the relevant I.S. Code will be followed for the procedure of surface preparation, placement, consolidation, curing, finishes, repairs and maintenance of concrete. If, however, there is no specific provision in the relevant I.S. Code for any particular aspect of work, any other standard Code of practice, as may be specified by the Engineer, will be adopted. Concrete may have to be placed against the following types of surfaces :

a) Earth foundation

b) Rock foundation

c) Formwork

d) Construction joint in concrete or masonry

The surface on or against which concrete is to be placed has to be cleaned thoroughly. Rock or old construction joint has to be roughened by wire brushing, chipping, sand blasting or any other approved means for proper bond. All cuttings, dirt, oil, foreign and deleterious material, laitance, etc. are to be removed by air water jetting or water at high pressure. All excavated areas for foundations, ring beams, plinths, pile caps etc. shall be rammed & consolidated properly before blinding with nominal mix plain concrete, as per drawing and / or direction of the Engineer and shall be allowed to cure prior to setting out steel fixing, shuttering and concrete pouring for the main structural element.

Formwork, reinforcement, preparation of surface, embedments, joint seals etc., shall be approved in writing by the Engineer before concrete is placed. As far as possible, concrete shall be placed in the formwork by means approved by the Engineer and shall not be dropped from a height or handled in a manner which may cause segregation. Any drop over 1500 mm shall have to be approved by the Engineer.

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.

Formwork will be cleaned thoroughly and smeared lightly with form oil or grease of approved quality just prior to placement.

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 and cement slurry will be spread thoroughly on the rock foundation or construction joint just prior to placement of concrete. The cost of application of such cement slurry and mortar will be deemed to be included.

After concrete has been placed, it shall be spread, if necessary and thoroughly compacted by approved mechanical vibration to maximum subsidence without segregation and thoroughly worked around shape. Vibrators shall not be used for pushing concrete into adjoining areas. Vibrators must be operated by experienced workmen and the work carried out as per relevant IS Code of Practice. In thin members with heavy congestion of reinforcement or other embedments, where effective use of internal vibrator is, in the opinion of the Engineer, doubtful, in addition to immersion vibrators the contractor may have to employ form vibrators conforming to IS:4656. For slabs and other similar structures, the contractor will additionally employ screed vibrator as per IS:2506. Hand tamping may be allowed in rare cases, subject to the approval of the Engineer. Care must be taken to ensure that the inserts, fixtures,

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

The rate of placement of concrete shall be such that no cold joint is formed and fresh concrete is placed always against green concrete which is still plastic and workable. No concrete shall be placed in open, during rains. During rainy season, no placement in the open is to be attempted unless sufficient tarpaulins or other similar protective arrangement for completely covering the still green concrete from rain is kept at the site of placement. If there has been any sign of washing of cement and sand, the entire affected concrete shall be removed immediately. Suitable precautions shall be taken in advance to guard against rains before leaving the fresh concrete unattended. No accumulation of water shall be permitted on or around freshly laid concrete.

The size of the concrete pours must be carefully considered prior to commencement to ensure the structural elements are poured in on contineous shift to avoid cold joints.

Slabs, beams and similar members shall be poured in one operation, unless otherwise instructed by the Engineer. Moulding, throating, drip course, etc., shall be poured as shown on the drawings or as directed by the Engineer. Holes shall be provided and bolts, sleeves, anchors, fastenings or other fixtures shall be embedded in concrete as shown on the drawings or as directed by the Engineer. Any deviation therefrom shall be set right by the Contractor as instructed by the Engineer.

In case the forms or supports get displaced during or immediately after the placement and bring the concrete surface out of alignment beyond tolerance limits, the Engineer may direct to remove the portion and reconstruct or repair the same.

The Engineer shall decide upon the time interval between two placements of concrete of different ages coming in contact with each other, taking in consideration the degree of maturity of the older concrete, shrinkage, heat dissipation and the ability of the older concrete to withstand the load imposed upon it by the fresh placement.

Once the concrete is deposited, consolidated and finished in its final position, it shall not be distributed.

### 3.13 Construction Joints and Cold Joints

#### 3.13.1 Construction Joints

It is always desirable to complete any concrete structure by continuous pouring in one operation. However, due to practical limitation of methods and equipment and certain design considerations, construction joints are formed by discontinuing concrete at certain predetermined stages. These joints will be formed in a manner specified in the drawings/ Instruction. Vertical construction joints will be made with rigid stop-board forms having slots for allowing passage of reinforcement rods and any other

embedments and fixtures that may be shown. Next stage concrete shall be placed against construction joint as per clause 3.12. For water retaining structures and leak-proof buildings suitable approved water bars will be installed at the construction joints.

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 within the middle third of the span.

c) A joint in a suspended floor slab shall be vertical and within the middle third 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 sub-mitted well in advance to the Engineer for study and approval without which no construction joint will be allowed.

3.13.2 **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 :

a) 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 systemetically vibrated.

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

c) In case the concrete at the joint has become so stiff that it cannot be remoulded and mortar or slurry does not rise inspite 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 clause 3.12.

## 3.14 Repairs, Finishes and Treatment of Concrete surfaces

3.14.1 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. 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. All concrete work shall be inspected by the Contractor immediately after the forms are removed and he will promptly report occurence 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 and shape.

c) Cleaning of reinforcement and embedments. It may be necessary to provide an anti-corrosive coating on the inforcement.

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 bycutting out defective concrete.

i) Groting with a cement sand slurry of 1:1 mix.

j) Repairing with a suitable mortar either cement or resin modified mortar.

k) Polyer modified patching and adhesive repair mortar for beams & columns.

3.14.2 **Finishing Unformed Surface**

A few typical and common cases of treatment of concrete surface are cited below :

a) **Floor**

Whenever a non-integral floor finish is indicated, the surface of reinforcement concrete slab shall be struck off at the specified levels and slopes and shall be finished with a wooden float fairly smooth removing all laitance. No overtrowelling, to obtain a very smooth surface, shall be done as it will prevent adequate bond with the subsequent finish. If desired by the Engineer, the surface shall be scored and marked to provide better bond.

Where monolithic finish is specified or required, concrete shall be compacted and struck off at the specified levels and slopes with a screed, preferably a vibrating type and then floated with a wooden float. Steel trowelling by hand or by rotary power float is then started after the moisture film and shine have disappeared from the surface and after the concrete has hardened enough to prevent excess of fines and water to rise to the surface but not hard enough to prevent proper finishing of aberrations. Steel trowelling properly done will flatten and smoothen sandy surface left by wooden floats and produce a dense surface free from blemishes, ripples and trowel marks. A fine textured surface that is not slick and can be used where there is likelihood of spillage of oil or water can be obtained by trowelling the surface lightly with a circular motion after initial trowelling keeping the steel trowel flat on the surface.

To provide a better grip the Engineer may instruct marking the floor in a regular geometric pattern after initial trowelling.

b) **Beams, Columns & Walls**

If on such or any other concrete structure it is intended to apply plaster or such concrete surfaces against which brickwork or other allied works are to be built, the Contractor shall hack the surface adequately as soon as the form is stripped off so that proper bond can develop. Pattern, adequacy and details of such hacking shall meet with the approval of the Engineer, who shall be informed to inspect such surfaces before they are covered up.

3.15 **Protection and Curing of concrete**

Newly placed concrete shall be protected by approved means from rain, sun and wind. Concrete placed below the ground level shall be protected against contamination from falling earth during and after placing. Concrete placed in ground containing deleterious substances, shall be protected from contact with such ground, or with water draining from such ground, during placing of concrete and for a period of at least three days or as otherwise instructed by the Engineer. The ground water around newly poured concrete shall be kept to an approved level by pumping out or other adequate means of drainage to prevent floatation or flooding. Steps, as approved by the Engineer, shall be taken to protect immature concrete from damage by debris, excessive loadings, vibration, abrasion, mixing with earth or other deleterious materials, etc. that may impair the strength and durability of the concrete.

As soon as the concrete has hardened sufficiently, it shall be covered either with sand, polythene sheet, hessian, canvas or similar materials and kept continuously wet for at least 14 (fourteen) days after final setting. Curing by continuous sprinkling of water will be allowed if the Engineer is satisfied with the adequacy of the arrangements made by the Contractor.

If permitted by the Engineer, curing compound like "ANTISOLE (WP)" may be used for prevention of premature water loss in concrete and thereby effecting curing of concrete . This type of curing compound shall be sprayed on newly laid concrete surfaces to form thin film barrier against premature water loss without disturbances to normal setting action. The curing compound shall comply with ASTM requirements for acceptance.

The curing compound shall be applied following the final finishing operation and immediately after disappearance of water sheen from concrete surface.

It is important not to apply the curing compound when standing water is still present on concrete.

The contractor shall arrange for the manufacturer's supervision.

The Contractor shall remain extremely vigilant and employ proper equipment and workmen under able supervision for curing. The Engineer's decision regarding the adequacy of curing is final. In case any lapse on the part of the Contractor is noticed by the Engineer, he will inform the Contractor or his supervisor verbally or in writing to correct the deficiency in curing. If no satisfactory action is taken by the Contractor within 3 (three) hours of issuance of such instruction, the Engineer will be at liberty either to employ sufficient means through any agency to make good the deficiency and entirely at the discretion of the Engineer.

## 3.16 Reinforcement

Mild steel round bars, cold twisted and deformed bars as medium tensile or high yield strength steel, plain hard drawn steel wire fabric etc., will be

used as reinforcement as per drawings and directions. In an aggressive environment an anti-corrosive coating on the reinforcement may be provided as per IS:9077, as shown on the drawing or as directed by the Engineer.

3.16.1 **Bar Bending Schedules**

The Contractor shall submit to the Engineer for approval Bar Bending Schedules with working drawings in triplicate, showing clearly the arrangements proposed by the Contractor to match available stock of reinforcing steel, within one month of receipt of the Letter of Intent or of the receipt of the relevant design drawings, whichever is later. Upon receipt of the Engineer's final approval of the Bar Bending Schedule and drawings, the Contractor shall submit 6 (six) prints of the final drawings with one reproducible print after incorporating necessary modifications or corrections, for final record and distribution. 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.

3.16.2 **Cleaning**

All steel for reinforcement shall be free from loose scales, oil, grease, paint or other harmful matters immediately before placing the concrete.

3.16.3 **Cutting & Bending of Reinforcement**

Unless otherwise specified, reinforcing steel shall be bent in accordance with the procedure specified in IS:2502 or as approved by the Engineer. Bends and shapes shall comply strictly with the dimensions corresponding to the approved Bar Bending Schedules. Bar Bending Schedules shall be rechecked by the Contractor before any bending is done.

No reinforcement shall be bent when already in position in the work, without approval of the Engineer, whether or not it is partially embedded in concrete. Bars shall not be straightened in a manner that will injure the material. Rebending can be done only if approved by the Engineer. Reinforcing bars above 16 mm diameter shall be bent by machine producing a gradual and even motion. Bars of 16 mm or below may be bent by hand. All the bars shall be cold bent unless otherwise approved. Bending hot at a cherry-red heat(not exceeding 845°C) may be allowed under very exceptional circumstances except for bars whose strength depends on cold working. Bars bent hot shall not be cooled by quenching.

Reinforcing bars, whether high yield or mild steel shall be cut using either hand held shears, guillotines or foot operated pneumatic cutters. Cutting bars using cold chisels may be allowed by the Engineer at exceptional cases.

3.16.4 **Placing in Position**

All reinforcements shall be accurately fixed and maintained in position as shown on the drawings by such approved and adequate means like

mild steel chairs and/or concrete spacer blocks irrespective of whether such supports are payable or not. Bars intended to be in contact at crossing points, shall be securely tied together at all such points by No. 20 G annealed soft iron wire. Tack welding of bars should not be done unless permitted by the Engineer. Binders shall tightly embrace the bars with which they 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 mild steel spacer bars. They should be spaced such that the main bars do not sag perceptibly between adjacent spacers. Before actual placing, the Contractor shall study the drawings thoroughly and inform the Engineer in case he feels that placement of certain bars is not possible due to congestion. In such cases he should not start placing any bar before obtaining clearance from the Engineer.

### 3.16.5 Welding

Normal bond laps in reinforcement may be placed by lap or butt welding reinforcement bars, if asked by the Engineer, under certain conditions. The work should be done with suitable safeguards in accordance with relevant Indian Standards for welding of mild steel bars used in reinforced concrete construction as per IS:2751 and IS:456. Welded mesh fabrics conforming to IS:1566 may also be used if specified in the Schedule of Items and Drawings.

### 3.16.6 Control

The placing of reinforcements shall be completed well in advance of concrete pouring. Immediately before pouring, the reinforcement shall be examined by the Engineer for accuracy of placement and cleanliness. Necessary corrections as directed by him shall be carried out. Laps and anchorage lengths 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 will guide the lap length. The laps shall be staggered as far as practicable and as directed by the Engineer. Arrangements for placing concrete shall be such that reinforcement in position do not have to bear extra load and get disturbed.

The cover for concrete over the reinforcements shall be as shown on the approved drawings unless otherwise directed by the Engineer. Where concrete blocks are used for ensuring the cover and positioning reinforcement, they shall be made of mortar not leaner than 1 (one) part cement to 2 (two) parts sand by volume and cured in a pond for at least 14 (fourteen) days. The type, shape, size and location of the concrete blocks shall be as approved by the Engineer.

## 3.17 Cold Weather Concreting

When conditions are such that any operation of concreting may be expected to be done at 5 Deg.C atmospheric temperature or below the work shall conform to the requirement of Clause 14 of IS:456 and IS:7861. (Part. II).

3.18 **Hot Weather Concreting**

When depositing concrete in very hot weather, the Contractor shall take all precautions as per IS:7861 (Part-I) and stagger the work to the cooler parts of the day to ensure that the temperature of wet concrete used in massive structures does not exceed 40 Deg.C while placing. Positive temperature control by precooling, postcooling or any other method, if required, will be specified.

3.19 **Concreting under water**

When it is necessary to deposit concrete under water it shall be done in accordance with the requirements of clause 14 of IS:456.

3.20 **Form Work**

3.20.1 **General**

Formwork shall conform to the shape, grade, lines, levels and dimension as shown on the drawings. The contractor shall prepare design & working drawings for formwork & temporary support system for important structures and get them approved by the Engineer prior to commencement of actual work.

Materials used for the formwork inclusive of the supports and centering shall be capable of withstanding the working load and remain undistorted throughout the period it is left in service. All supports and scaffolds should be manufactured from structural or tubular steel except when specifically permitted otherwise by the Engineer.

The centering shall be true to vertical, rigid and thoroughly braced both horizontally and diagonally. Rekers are to be used where forms are to support inclined members. The forms shall be sufficiently strong to carry without undue deformation, the dead weight of the concrete as a liquid as well as the working load, in case the Contractor wishes to adopt any other design criteria, he has to convince the Engineer about its acceptability before adopting it. 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 slurry or mortar.

To achieve the desired rigidity, tie bolts, spacer blocks, tie wires and clamps as approved by the Engineer shall be used but they must in no way impair the strength of concrete or cause 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. Alternatively, except in case of water retaining structures through rods and the tie bolts shall be sleeved with PVC conduits to allow retraction of the ties on removal of the shutters. Where required, the annulus of the conduits will be filled with expanding mortar to seal the void. Bolts passing

completely through liquid retaining walls/slabs for the purpose of securing and aligning the formwork shall not be used.

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 Engineer immediately and rectified as directed by him.

For exposed interior and exterior concrete surfaces of beams, columns and wall, plywood or other approved form shall be thoroughly cleaned and tied together with approved corrosion- resistant devices. Rigid care shall be exercised in ensuring that all column forms are plumb and true and thoroughly cross braced to keep them so. All floor and beam centering shall be crowned not less than 8 mm in all directions for every 5 metres span.Unless specifically described on the drawings or elsewhere to the contrary, bevelled forms 25 mm by 25 mm shall be fixed in the form-work at all corners to provide chamfering of the finished concrete edges. The formwork should lap and be secured sufficiently at the lift joints to prevent bulges and offsets.

Temporary openings for cleaning, inspection and for pouring concrete shall be provided at the base of vertical forms and at other places, where they are necessary and as may be directed by the Engineer. The temporary openings shall be so formed that they can be conveniently closed when required, during pouring operations without leaving any mark on the concrete.

3.20.2 **Cleaning and Treatment of Forms**

All parts of the forms shall be thoroughly cleaned of old concrete, wood shavings , saw dust, dirt and dust sticking to them before they are fixed in position. All rubbish, loose concrete, chippings, shavings, saw dust etc. shall be scrupulously removed from the interior of the forms before concrete is poured. Compressed air jet and/or water jet along with wire brushes, brooms etc. shall be used for cleaning. The inside surface of the formwork shall be treated with approved non-staining oil based shutter release agent like "Separol/Sika form oil/ Siparol Concentrate" before it is placed in position. Care shall be taken that oil or other compound does not come in contact with reinforcing steel or construction joint surfaces. They shall not be allowed to accumulate at the bottom of the formwork. The oiling of the formwork will be inspected just prior to placement of concrete and redone wherever necessary.

3.20.3 **Design**

The formwork shall be so designed and erected that the forms for slabs and the sides of beams, columns and walls are independent of the soffits of beams and can be removed without any strain to the concrete already placed or affecting the remaining formwork. Removing any props or repropping shall not be done except with the specific

approval of the Engineer. If formwork for column is erected for the full height of the column, one side shall be left open and built up in sections, as placing of concrete progress. Wedges, spacer bolts, clamps or other suitable means shall be provided to allow accurate adjustment and alignment of the formwork and to allow it to be removed gradually without jarring the concrete.

The design of formwork shall take into account all vertical and lateral loads that the forms will carry or be subjected to during the construction process. Besides weight and pressures of reinforced concrete and weight of the forms themselves, the design shall consider loading due to unsymmetrical placement of concrete ; impact from dumping of concrete ; movement of men and construction equipment ; wind action and any other imposed load during construction. The contractor shall assess the magnitude of vertical live load to be taken for design of formwork duly considering his method, sequence and rate of pouer of concrete. However, minimum design vertical live load to be considered shall be 750 kg/sqm excluding weight of concrete.

3.20.4 **Inspection of Forms**

Casting of Concrete shall start only after the formwork has been inspected and approved by the Engineer. The concreting shall start as early as possible within 3 (three) days after the approval of the formwork and during this period the formwork shall be kept under constant vigilance against any interference. In case of delay beyond three days, a fresh approval from the Engineer shall be obtained.

3.20.5 **Removal of Forms**

Before removing any formwork, the Contractor must notify the Engineer well in advance to enable him to inspect the concrete if he so desires. The Contractor shall record on the drawing or in any other approved manner, the date on which concrete is placed in each part of the work and the date on which the formwork is removed therefrom and have this record checked and countersigned by the Engineer regularly.

The Contractor shall be responsible for the safe removal of the formwork and any work showing signs of damage through premature removal of formwork or loading shall be rejected and entirely reconstructed by him. The Engineer may, however, instruct to postpone the removal of formwork if he considers it necessary.

Forms for various types of structural components shall not be removed before the minimum periods specified herein and the removal after the minimum periods shall also be subject to the approval of the Engineer in each case.

# VOLUME – II B
## CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

## SPECIFICATION NO. PE-TS-411-620-C001

## SECTION - D

## *GENERAL TECHNICAL SPECIFICATION*

## FORMWORK

**Bharat Heavy Electricals Limited**
**Project Engineering Management**
**PPEI Building, Power Sector,**
**Plot No. 25, Sector 16A,**
**Noida (U.P.)-201301**

## TABLE - IV

## SCHEDULE OF REMOVAL OF FORM

| Part of Structure | Ordinary Portland Cement Concrete | | | | Rapid Hardening Portland Cement Concrete | | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature Deg.C | | | | Temperature Deg.C | | | |
| | Above 40 Deg.C | 40 Deg.- 20 Deg. | 20 Deg.-Below 5 Deg. | 5 Deg. | Above 40 Deg. | 40 Deg.- 20 Deg. | 20 Deg.- Below 5 Deg. | 5 Deg. |
| | Days | Days | Days | Days | Days | Days | Days | Days |
| a) Columns & Walls | 2 | 1 | 1 | Do not remove forms until site cured test specimen develop at least 50% of the specified 28 days strength | 1 | 1 | 1 | Do not remove forms until site cured test specimen develop at least 50% of the specified 28 days strength |
| b) Beam sides | 3 | 2 | 3 | | 2 | 1 | 1 | |
| c) Slabs, 125 mm | 10 | 7 | 8 | | 7 | 4 | 5 | |
| d) Slabs over 125 mm thick and soffit of minor beams | 18 | 14 | 16 | | 12 | 8 | 9 | |
| e) Soffit of main beams | 24 | 21 | 22 | | 14 | 10 | 12 | |

Wherever exposed surfaces of concrete can be effectively sealed to prevent loss of water, the periods specified for temperature above 40 Deg.C can be reduced to those of the temperature range of 20 Deg.C to 40 Deg.C subject to approval of the Engineer.

Construction joints in beams, if required to be provided, will be located within the middle third of span according to clause 3.13.1(b) of this specification. In such cases, however, entire span of beam shall have to be kept supported by formwork till its removal for the portion of beam, cast at a later date, is due and so approved by the Engineer.

If any type of cement other than ordinary portland cement and Rapid hardening portland cement is used the time of removal or forms shall be revised as approved by the Engineer such that the strength of this cement at the time of removal of forms match with strength of portland cement at

the time of removal of form as mentioned above . This has to be supported by regular tests.

3.20.6 **Tolerance**

The formwork shall be so made as to produce a finished concrete, true to shape, lines, levels, plumb and dimensions as shown on the drawings subject to the following tolerances unless otherwise specified in this Specification or drawings or directed by the Engineer :

**For**

a) Sectional dimension - ± 5 mm

b) Plumb - 1 in 1000 of height

c) Levels - ± 3 mm before any deflection has taken place

The tolerance given above are specified for local aberrations in the finished concrete surface and 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.

3.20.7 **Re-use of Forms**

Before re-use, all forms shall be thoroughly scraped, cleaned, joints and planes examined and when necessary repaired, and inside surface treated as specified hereinbefore. Formwork shall not be used/re-used if declared unfit or unserviceable by the Engineer.

3.20.8 **Classification**

Generally, the 'ordinary' class formwork shall be used unless otherwise directed by the Engineer :

a) Ordinary : These shall be used in places where ordinary surface finish is required and shall be composed of steel and/or approved good quality partially seasoned timber.

b) Plywood : These shall be used in exposed surfaces, where a specially good finish is required and shall be made of approved brand of heavy quality plywood to produce a perfectly uniform and smooth surface conforming to the shape described in the drawing with required grain texture on the concrete. Re-use may only be permitted after special inspection and approval

by the Engineer. He may also permit utilisation of used plywood for the 'ordinary' class, if it is still in good condition.

c) Ornamental: 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.

3.21 **Opening, Chases, Grooves, Rebates, Blockouts etc.**

The Contractor shall leave all openings, grooves, chases, etc. in concrete work as shown on the drawings or as specified by the Engineer.

3.22 Anchor Bolts, Anchors, Sleeves, Inserts, Hangers/Conduits/Pipe and Other misc. Embedded Fixtures. The Contractor shall build into concrete work all the items noted below and shall embed them partly or fully as directed and secure the same as may be required. The materials, if required to be supplied by the Contractor, shall be as specified and be of best quality available according to relevant Indian Standards of approved manufacture and to the satisfaction of the Engineer. Exposed surfaces of embedded materials are to be painted with one coat of approved anti-corrosive paint and/or bituminous paint. If welding is to be done subsequently on the exposed surface of embedded material the paint shall be cleaned off the member to a minimum length of 50 mm beyond each side of the weld line.

Necessary templates, jigs, fixtures, supports etc. shall be used as may be required or directed by the Engineer. Items to be embedded.

a) Inserts, hangers, anchors, frames around openings, manhole covers, frames, floor clips, sleeves conduits and pipes.

b) Anchor bolts and plates for machinery, equipment and for structural steel work.

c) Steel structurals to be left embedded for future extension, special connection etc.

d) Lugs or plugs for door and window frames occurring in concrete work.

e) Flashing and jointing in concrete work.

f) Any misc. embedments and fixture as may be required.

Correct location and alignment, as per drawings/instruction of all these embedded items shall be entirely the responsibility of the Contractor.

3.23 **Expansion and Isolation Joints**

3.23.1 **General**

Expansion and isolation joints in concrete structures shall be provided at specific places as per details indicated on the drawings. The materials and types of joints shall be as specified hereinafter. In case of liquid retaining structures, additional precautions shall be taken to prevent leakage of liquids as may be specified on the drawings or as directed by the Engineer. All materials are to be procured from reliable manufacturers and must have the approval of the Engineer. Where it is the responsibility of the Contractor to supply the material, the Engineer may demand test certificates for the materials and/or instruct the Contractor to get them tested in an approved laboratory. Joints shall be formed true to line, level, shape, dimension and quality as per drawings and specifications. Prior approval of the method of forming the joints should be obtained from the Engineer before starting the work.

3.23.2 **Bitumen Board/Expanded Polystyrene Board**

a) **Bitumen Board**

Bitumen impregnated fibre board of approved manufacturer as per IS:1838 may be used as fillers for expansion joints. It must be durable and waterproof. It shall be compressible and possess a high degree of rebound. The dimensions of the board should be equal to that of the joint being formed. It should, preferably be manufactured in one piece, matching the dimension of the joint and not prepared by cutting to size smaller pieces from larger boards at site. At the exposed end, the joint shall be sealed with approved sealing compound to a depth of at least 25 mm after application of an approved primer. The sealing compound and the primer shall be applied as specified by the manufacturer.

b) **Expanded Polystyrene Boards**

If required, commercial quality\of expanded polystyrene products commonly used for thermal insulations may also be used as filler material in expansion joints. The thickness may vary from 12 mm to 50 mm. The material will have to be procured from reliable manufacturers as approved by the Engineer. The method of installations will be similar to that recommended by the manufacturers for fixing on cold storage walls. A coat of Bitumen paint may have to be applied on the board against which concrete will be placed.

3.23.3 **Joint Sealing Strips**

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 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 vulcanised.

Non - metallic sealing strips 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, 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 and the edges accurately.

a) **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 of items and/or as 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 Deg.C

Ultimate Elongation : Not less than 350%

b) **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/schedule of items and/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 80A

Tensile Strength : 10 - 15 N/Sq.mm

Maximum Safe Continuous Temperature : 70 Deg.C

Ultimate Elongation : Not less than 275%

3.23.4 **Joint Sealing Compound**

When directed, the gap in expansion joints shall be thoroughly cleaned and bitumen compound laid as per manufacturer's specifications. The compound to be used shall be of approved manufacture and shall conform to the requirements of IS:1834.

Alternatively, when directed , the expansion Joints may be filled with joint sealing compound like "Sikalastic" or approved equivalent and shall be applied as per manufacturer's specification.

3.23.5 **Isolation Joints**

Strong and tough alkathene or PVC sheet about 1 mm in thickness and as approved by the Engineer shall be used in isolation joints. It shall be fixed by an approved adhesive compound on the cleaned surface of the already set concrete, to cover it fully. Fresh concrete shall be laid against the sheet, care being taken not to damage the sheet in any way.

3.23.6 **Rubber Pad**

Hard foundation quality rubber pads of required thickness and shapes shall be put below machine or other foundations as shown on the drawings or as directed by the Engineer. The rubber shall have a unit weight of 1500 Kg/Cu.m, a shore hardness - 65A to 70A and be of best quality of approved manufacture, durable, capable of absorbing vibration and must be chemically inert in contact with moist or dry earth or any other deleterious material expected under normal conditions.

3.24 **Grouting under Machinery or Structural Steel Bases**

If required, grouting under base plates of machines or structural steel etc. shall be carried out by the Contractor. In general, the mix shall be 1 (one) part cement and 1 (one) part sand and just enough water to make it flow as required. The areas to be grouted shall be cleaned thoroughly with compressed air jet and/or with water in locations where accumulated surplus water can be removed. Where directed by the Engineer, 6 mm down stonechips may have to be used in the mix. Surface to be grouted shall be kept moist for at least 24 hours in advance. The grout shall be placed under expert supervision, so that there is no locked up air. Edges shall be finished properly. If desired by the Engineer, admixtures like Aluminium powder, 'Ironite' etc. may have to be added with the grout in proportions to be decided by the Engineer. Admixture, if directed to be added, will be measured and paid separately.

Alternatively non-shink , free flow, cementious grout like "Sikagrout 214/ Ankor NSG" or approved equivalent specifically selected for the type of equipment to be located (vibrating, static etc.) may also be used for grouting as per manufacturer's specification with necessary approval of the Engineer.

3.25 **Precast Concrete**

The Specification for precast concrete will be similar as for the cast-in-place concrete described herein and as supplemented in this section. All precast work shall be carried out in a yard made for the purpose.

This yard shall be dry, properly levelled and having a hard and even as well as well drained surface to prevent excessive uneven settlement due to softening of soil during casting & curing. If the ground is to be used as a soffit former of the units, it shall be paved with concrete or masonry and provided with a layer of plaster (1:2 proportion) with smooth neat cement finish or a layer of M.S. sheeting. Where directed by the Engineer, casting

will have to be done on suitable vibrating table. The yard, lifting equipment, curing tank, finished material storage space etc. shall be designed such that the units are not lifted from the mould before 10 (Ten) days of curing and can be removed for erection after 28 (twenty eight) days of curing. The moulds shall preferably be of steel or of timber lined with G.I. sheet metal and must be rigid enough to prevent distortion during placing and compaction of the concrete.

Other than normal curing by applying water through spray nozzles or perforated hose curing by high pressure steam, steam vapour or other accepted processes may also be employed to accelerate the hardening of the concrete and to reduce the curing time.

Lifting hooks, where necessary or as directed by the Engineer, shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drawings, and shall be burnt off and finished after erection.

All members shall be imdelibly marked with a unique identification mark on a surface which will not be permanently exposed to show on which production line they were manufactured , their type , the class of concrete, the data of casting and if they are of a symmetrical section the face which will be uppermost when the member is in its correct position after erection.

Precast concrete units, when ready, shall be transported to site by suitable means approved by the Engineer. Care shall be taken to ensure that no damage occurs during transportation. All adjustments, levelling and plumbing shall be done as per instructions of the Engineer. The Contractor shall render all help with instruments, materials and men to the Engineer for checking the proper erection of the precast units.

After erection and alignment, the joints shall be filled with grout or concrete as directed by the Engineer. If centerings have to be used for supporting the precast units, they shall not be removed until the joints have attained sufficient strength and in no case before 14 (fourteen) days. The joint between precast roof planks shall be pointed with 1:2 cement : sand mortar where called for in the drawings.

## 3.26 Waterproofing of Concrete Structure

### 3.26.1 General

Waterproofing of concrete structures shall be done by either suitable extraneous treatments like applying waterproofing paints like "Sikatop Seal" fixing bitumen felts etc. or internally by suitable design of the concrete mix, addition of suitable admixtures conforming to IS:2645 and equivalent American or British codes in the concrete or mortar at the time of mixing and/or installing water bars at the joints.

The design, material and workmanship shall conform to the relevant I.S. Codes where applicable. The Engineer's approval of the materials shall be obtained by the Contractor before procurement. If desired by the Engineer, test certificates for the materials and samples shall be submitted by the Contractor. The materials shall be of best quality available indigenously, fresh clean and suitable for the duties called upon.

3.26.2 **Water Bar/Seal/Special Treatment of Construction Joint**

Water bearing structures and underground structures may have water bar/seals installed at the joints. They may be rubber or P.V.C. The materials and installation will be as described under Clause 3.23.3. Construction joint should be provided as per clause 3.13.1 with or without water bar / Seal as shown on the drawing. In case of water bars being used at the construction Joint, fixing of the same has to be done carefully so that the water bar is not disturbed during concreting. The construction joint shall also be treated by any one of the following methods :

Method 1 : 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 | - | 25 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. mm ( approx) |

The whole operation shall be done as per manufacturer's specification. The contractor shall provide manufacturer's supervision.

Method 2 : One row of threaded nozzles at regular intervals not exceeding 1.5 m centre to centre shall be placed in concrete along the construction joint during casting. Injection of cement water together with a suitable

waterproof expanding grouting admixture of approved quality shall be done through the nozzles after the construction joint in walls and slabs. The injection shall be done under pressure of approximately 2 to 4 Kg/Sq cm . The nozzles shall be sealed off with suitable admixture after the injection is over. The whole operation shall be carried out as per manufacturer's specification and supervision.

3.26.3 **Waterproofing Admixtures**

The waterproofing admixture for concrete and cement mortar / plaster shall conform to relevant IS code. The admixture shall not cause decrease of strength of concrete / plaster at any stage and it is 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 resistant concrete admixture shall be used to provide a waterproof concrete around 410 Kg/ Cm.m a melamine based super plasiticizer will be preferable.

a) In concrete : The approved admixture shall be based on modified lignosulphonate like "Plastocrete - N/Super" or approved equivalent. 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 to supervise the work, if desired by the Engineer.

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 like "Noleak CP/Sika Latex" or approved equivalent 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. On completion, the plastered surface shall be cured continuously for a minimum period of 14 days like concrete.

3.26.4 **Bituminous or Tar Coating on External Surface**

The surface to be waterproofed shall be rendered absolutely dry, clean and dust free. The surface shall be sand papered, cleaned and completely coated with hot coal tar pitch of approved manufacturer and quality as per IS:216 (not heated above 375 Deg.F) using not less than 2 Kg. per Sq.M. or with hot asphalt i.e., bitumen according to IS:73 (not heated above 400 Deg.F) using not less than 1.5 kg. per Sq.M. When the first coat has completely dried up and approved by the Engineer, the second coat shall be applied in the same manner using not less than 1.25 Kg. per Sq.M. in case of coal tar and 1 Kg. per Sq.M. in case of asphalt. Immediately after application of the second coat and before it is dried up, sand shall be spread on the surface to cover it completely. Sufficient time shall be allowed after spreading of sand before backfilling is done in order to allow the final coat to dry up completely. In place of hot application by coal tar / asphalt the coating of the outside surfaces of walls may be carried out using a ready to use liquid, bituminous emulsion/rubber protective coating of approved manufacturer.

3.26.5 **Protective Coating on Inside Surface**

Two coats or cement based to 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.

3.26.6 **Bitumen Felt : Application 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 shall be hessian base and/or fibre base as specified in Drawing/Schedule of Items. If required by the Engineer, tests as specified in relevant IS Codes shall be arranged by the Contractor.

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

Cleaning the surface, keeping it dry, providing necessary corner fillets and cement rendering and cutting chases, etc. shall be included in the rate for this item. If any protective brickwork on/against concrete sub-bases or walls are required, these will be paid extra under suitable items in the contract. A 20 (twenty) years' guarantee for satisfactory performances shall be given by the Contractor as well as his specialist sub-contractor jointly and severally, for this item of 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.

3.26.7 Polyethelene Films : Application in Walls or base of Structures

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

i) the concrete surface shall be made smooth with 12 mm cement plaster 1:6

ii) apply hot bitumen 80/100 grade (IS:73-1961) at the rate of 1.0 Kg/Sq.m minimum

iii) lay black polyethelene 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 polyethelene 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 celophane tape is to be spread and on this the LDPE film, with 100 mm overlap, is to be stretched. On the overlapped film another celophane 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 celophane tape is to be removed and the joints are to be tested for leaks.

iv) Lay 100 gm brown craft paper laminated with a layer of straight run bitumen.

v) Lay hot bitument 80/100 grade (IS:73-1961) at 1.0 Kg/Sq.m minimum.

vi) Lay 250 micron polyethelene film as second layer similar to (iii) above.

vii) Lay second layer of 100 gm. brown craft paper laminated similar to (iv) above.

viii) Apply hot bitumen (straight run grade) to IS:73-1961 at 1.0 Kg/Sq.m dusted with fine sand.

ix) Protecting with a layer of 75 mm plain cement concrete M-100, 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.

### 3.27 Protective coating on Concrete Surface

### 3.27.1 On Foundation

The outside faces of foundation of important structures will be protected from adverse effect of soil/ underground water, if shown on drawing or instructed by the Engineer , by using bitumen emulsion protective coating of approved manufacturer.

3.28 **Waterproofing by Pressure /Chemical Grouting**

Where required, waterproofing for underground concrete structure shall be done by injecting high polymer based non- shrink waterproof grouting compound through nozzle under pressure as per manufacturer's recommendation. The pressure during injection shall not be less than 2.5 kg/Sq.cum and the thickness of epoxy resinous emulsion waterproof paint (to be applied on the external surface of walls/slabs) shall not be less than 700 microns.

## 4.0 SAMPLING AND TESTING

### 4.1 General

The Contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost unless otherwise specified in this specification. The Contractor shall get the specimens tested in a laboratory approved by the Engineer and submit to the Engineer the test results in triplicate within 3 (three) days after completion of the test.

### 4.2 Cement

Representative samples will be taken from each consignment of cement received from the manufacturer/supplier for carrying out the tests for fineness (by hand sieving), setting time and compressive strengths. Soundness Tests may also be required to be carried out if required by the Engineer. The tests shall be carried out free of charge by the Owner if cement is supplied by him. In case the Contractor is directed to arrange for the supply of cement as per the terms and conditions of the Contract the tests shall be carried out by him. In case due to any circumstances, the agency of supply is changed in the middle of the Contract, the party who bore the original contractual obligation will carry on with the test, free of charge to the other, till the end of the job. No cement from a particular consignment/batch will be used on the works unless satisfactory 3 (three) days and 7 (seven) days test results for compressive strength are known. The Owner, Engineer and Contractor will jointly associate themselves with the tests irrespective of whether they are carried out by the Owner or the Contractor. These tests are of great importance as their results will have a bearing on the acceptance of concrete or otherwise as per the terms and conditions of the Contract.

### 4.3 Aggregates

The Contractor shall carry out any or all the tests aggregates as may be required by the Engineer in accordance with IS:2386 PARTS-I to VIII. The acceptance criteria of the samples tested shall be in accordance with the requirements of the relevant Indian Standards.

### 4.4 Water

Sampling and Testing of water being used for concrete works as per IS:3550 will be carried out by the Contractor at regular intervals and whenever directed by the Engineer. The final acceptance criteria in case of doubt will be as per IS:3025 & IS:456.

## 4.5 Admixture

### 4.5.1 Air Entraining Agents (A.E.A)

Initially, before starting to use A.E.A., relationship between the percentage of air entrained and the cube crushing strength vis-a-vis quantity of A.E.A. used for all types of concrete will be established by the Contractor by carrying out sufficiently large number of tests. After then, at regular intervals and whenever directed by the Engineer, the Contractor will check up the actual percentages of air entrained and corresponding crushing strengths to correlate with the earlier test results.

### 4.5.2 Other Admixtures

Tests for establishing the various properties of any other admixtures which may be required to be added shall be carried out by the Contractor.

## 4.6 Concrete

The sampling of concrete, making the test specimens, curing and testing procedure etc. shall be in accordance with IS:516 and IS:1199 the size of specimen being 15 cm cubes. Normally, only compression tests shall be performed but under special circumstances the Engineer may require other tests to be performed in accordance with IS:516.

Sampling procedure, frequency of sampling and test specimen shall conform to Clause 14 of IS:456.

To control the consistency of concrete from every mixing plant, slump tests and/or compacting factor tests in accordance with IS:1199 and as mentioned in Clause 3.6 of this Specification shall be carried out by the Contractor every two hours or as directed by the Engineer. Slumps corresponding to the test specimens shall be recorded for reference.

The acceptance criteria of concrete shall be in accordance with Clause 15 of IS:456.

Concrete work found unsuitable for acceptance shall have to be dismantled and replacement is to be done as per specification by the Contractor. No payment for the dismantled concrete, the relevant formwork and reinforcement, embedded fixtures, etc. wasted in the dismantled portion shall be made. In the course of dismantling, if any damage is done to the

embedded items or adjacent structures, the same shall be made good to the satisfaction of the Engineer.

## 5.0 ACCEPTANCE CRITERIA

### 5.1 Standard Deviation

Standard deviation shall be based on test results and determination of Standard deviation shall conform to clause 16 of IS:456.

### 5.2 Acceptance Criteria

The strength requirements and acceptance criteria shall conform to Clause 16 of IS:456.

### 5.3 Inspection and Core Tests

Inspection of concrete work immediately after stripping the formwork and core test of structures shall conform to Clause 17 of IS:456.

### 5.4 Load Test

Load tests of structural members may be required by the Engineer, when the strength of test specimen results fall below the required strength, as per 'Load Test on Parts of Structures', Clause 17.6 of IS:456. If load testing is decided by the Engineer, the member under consideration shall be subjected to a test load equal to 1.25 (one and a quarter) times the specified live load used for design and this load shall be maintained for a period of 24 (twenty four) hours before removal. The detailed procedure of the test is to be decided by the Engineer. Load tests shall not be made until the structure is at least 56 days old.

If the member shows evident failure, such changes as are necessary to make the structure adequately strong shall be made by the Contractor. Alternatively, if permitted under Statutory Regulations and at the discretion of the Engineer, the structure under test or a portion thereof may be retained as such without any modification by derating its load bearing capacity, provided the design criteria allows such derating.

A reinforced concrete beam, floor or roof shall be deemed to have passed the test if the maximum deflection at the end of 24 hours does not exceed the deflection given in Clause 17.6 of IS:456.

The entire cost of load testing shall be borne by the Contractor. If a portion of the structure is found to be unacceptable, it shall be dismantled and replaced by a new structure as per specification.

If, in the course of dismantling, any damage is done to the embedded items and or other adjacent structures, the same will be made good by the Contractor to the satisfaction of the Engineer.

## 6.0 LIST OF I.S. CODES AND STANDARDS FOR REFERENCE

All work under this specification shall, unless specified otherwise, conform to the latest revisions and/or replacements of the following or any other Indian Standard Specifications and Codes of Practice. In case any particular aspect of work is not specifically covered by Indian Standard Specifications, any other standard practice, as may be specified by the Engineer, shall be followed :-

| | | |
|---|---|---|
| IS : 73 | - | Indian Standard Specification for Paving Bitumen |
| IS : 216 | - | Indian Standard Specification for Coal Tar Pitch |
| IS : 269 | - | Indian Standard Specification for 33 grade Ordinary Portland Cement |
| IS : 383 | - | Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete |
| IS : 432 | - | Indian Standard Specification for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for concrete Reinforcement - Part 1 & 2 |
| IS : 455 | - | Indian Standard Specification for Portland Slag Cement |
| IS : 456 | - | Indian Standard Code of Practice for Plain and Reinforced Concrete |
| IS : 457 | - | Indian Standard Code of Practice for General Construction of Plain and Reinforced Concrete for Dams and other Massive Structures |
| IS : 516 | - | Indian Standard Specification for Methods of Test for Strength of Concrete |
| IS : 737 | - | Indian standard specification for wrought Aluminium and Aluminium Alloy sheet and strip for general Engineering purpose. IS : 1199 - Indian Standard Specification for Methods of Sampling and Analysis of Concrete |
| IS : 1200 | - | Indian Standard Specification for Method of (Part-II) Measurement Cement Concrete Works. |
| IS : 1200 | - | Indian Standard Specification for Method of (Part-V) Measurement of Formwork |
| IS : 1322 | - | Indian Standard Specification for Bitumen Felts for Waterproofing and Damp-proofing |

| | | |
|---|---|---|
| IS : 1489 | - | Indian Standard Specification for Portland - Pozzolona Cement - Part 1 & 2 |
| IS : 1566 | - | Indian Standard 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 | - | Indian Standard Specification for high strength deformed Bars & wires for Concrete Reinforcement |
| IS : 1791 | - | Indian Standard Specification for Batch Type Concrete Mixers |
| IS : 1834 | - | Indian standard specification for hot applied sealing compound for joint in concrete. |
| IS : 2062 | - | Steel for general structural purpose. |
| IS : 2185 | - | Indian Standard Specification for Hollow and solid / solid light wt. Cement Concrete Blocks - Part - 1 & 2 |
| IS : 2210 | - | Indian Standard Specification for Design of Reinforced Concrete Shell Structures and Folded Plates |
| IS : 2386 | - | Indian Standard Specification for Methods of Test for Aggregates for Concrete - Part-I to VIII |
| IS : 2430 | - | Indian standard specification for method of sampling of Aggregate for concrete. |
| IS : 2502 | - | Indian Standard Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement |
| IS : 2505 | - | Indian Standard Specification for Concrete Vibrators Immersion Type |
| IS : 2506 | - | Indian Standard Specification for Screed Board Concrete Vibrators |
| IS : 2514 | - | Indian Standard Specification for Concrete Vibrating Tables |
| IS : 2645 | - | Integral Cement water proofing compound |
| IS : 2722 | - | Indian Standard Specification for Portable Swing Weigh Batchers for Concrete (Single and Double Bucket type) |
| IS : 2751 | - | Code of Practice for Welding of Mild Steel Bars used for Reinforced Concrete Construction |

| | | |
|---|---|---|
| IS : 2770 | - | Indian Standard Specification for Method of Testing Bond in Reinforced Concrete. Part - 1 : Pull out Test |
| IS : 3025 | - | Indian Standard Specification for Methods of Sampling and Test (Physical and Chemical) for Water & waste water - art - 1 to 37 |
| IS : 3201 | - | Indian Standard Specification for Design and Construction of Precast Concrete Trusses and purlins. |
| IS : 3370 | - | Indian Standard Specification for Code of Practice for Concrete Structures for Storage of Liquids Part 1 to 4 |
| IS : 3384 | - | Indian standard specification for / Bitumen primer for use in waterproofing and Danp proofing |
| IS : 3414 | - | Code of practice for Design and Installation of joints in Buildings |
| IS : 3550 | - | Indian Standard Specification for Method 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 | - | Safety Code for Part-1 : Scaffolding and Part 2: Ladders |
| IS : 3812 | - | Indian Standard Specification for Fly Ash for Use as Pozzolone & Admixture |
| IS : 4031 | - | Indian Standard Specification for Method of Tests for Hydraulic Cement - Part - 1 to 14 |
| IS : 4082 | - | Indian Standard Specification for Recommendation on Stacking and Storage of Construction Materials at site |
| IS : 4090 | - | Indian Standard Specification for Design of Reinforced Concrete Archs |
| IS : 4634 | - | Indian Standard Specification for Method of Testing Performance of Batch-type Concrete Mixers |
| IS : 4656 | - | Indian Standard Specification for Form Vibrators for Concrete |
| IS : 4925 | - | Indian Standard Specification for Concrete Batching and Mixing Plant |
| IS : 4926 | - | Indian Standard Specification for Ready Mixed Concrete |

| | | |
|---|---|---|
| IS : 4990 | - | Indian Standard Specification for Plywood for Concrete Shuttering work |
| IS : 4991 | - | Indian Standard Specification for Blast Resistant Design of Structure for Explosion above ground |
| IS : 4995 | - | Indian Standard Specification for Design (Part-I of Reinforced Concrete Bins for the Storage & II) of Granular and Powdery Materials |
| IS : 4998 | - | Indian Standard Specification for Design of (Part - I) Reinforced Concrete Chimneys |
| IS : 5512 | - | Indian Standard Specification for Flow Table for use in Tests of Hydraulic Cement and Pozzolanic Materials |
| IS : 5513 | - | Indian Standard Specification for Vicat Apparatus |
| IS : 5515 | - | Indian Standard Specification for Compaction Factor Apparatus |
| 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 : 6452 | - | Indian Standard Specification for High Alumina Cement for Structural Use |
| IS : 6909 | - | Indian Standard Specification for Supersulphated 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 |
| IS : 7251 | - | Indian Standard Specification for Concrete Finishers |
| IS : 7320 | - | Indian Standard Specification for Concrete Slump Test Apparatus |

| | | |
|---|---|---|
| IS : 7861 | - | Indian Standard Specification for (Part-I Recommended Practice for hot and cold & II) Weather Concreting |
| IS : 7969 | - | Safety Code for Storage and Handling of Building Materials |
| IS : 8041 | - | Indian Standard Specification for Rapid Hardening Portland cement |
| IS : 8043 | - | Indian standard specification for hydrophobic cement |
| IS : 8112 | - | Indian Standard Specification for 43 grade 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 : 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 Rails in RB and RCC Construction |
| IS : 9103 | - | Indian Standard Specification for Admixtures for Concrete. |
| IS : 9417 | - | Recommendation for welding cold worked bars for reinforced concrete construction |
| IS : 10262 | - | Recommended Guideline for concrete Mix Design |
| IS : 12269 | - | Indian standard specification for 53 gradeordinary portland cement |
| IS : 12330 | - | Indian standard specification for sulplate resting portland cement |
| IS : 12600 | - | Indian standard specification for low heat portland cement |

# VOLUME – II B
## CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

## SPECIFICATION NO. PE-TS-411-620-C001

## SECTION - D

## *GENERAL TECHNICAL SPECIFICATION*

## FABRICATION OF STRUCTURAL STEELWROK

**Bharat Heavy Electricals Limited**
**Project Engineering Management**
**PPEI Building, Power Sector,**
**Plot No. 25, Sector 16A,**
**Noida (U.P.)-201301**

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# TECHNICAL SPECIFICATION FOR FABRICATION OF STRUCTURAL STEELWORK

## 1.00 SCOPE

This specification covers supply of all raw steel materials, fabrication, testing, painting and delivery to site of structural steelwork including supply of all consumable stores and bolts, nuts, washers, electrodes and other materials required for fabrication and field connections of all structural steelwork in general covered under the scope of the contract. However, for any special structures such as rail & road bridges, steel chimney, tanks, transmission towers, furnace structures, etc., the relevant Indian Standard or IRC specification and Codes of Practices shall be given due consideration over & above this specification.

## 2.00 GENERAL

2.1.0 Work to be provided for by the Contractor

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

a) Preparation of complete detailed fabrication drawings and erection marking drawings required for all the structures covered under the scope of the contract based on contractor's design drawings approved by the Owner / Consultants.

b) To submit revised design with calculations and detailed fabrication drawings in case any substitution of the designed sections are to be made.

c) To submit design calculations for joints and connections developed by the contractor along with detailed fabrication drawings.

d) Furnish all materials, labour, tools and plant and all consumables required for fabrication and supply, all necessary bolts, nuts, washers, tie rods and welding electrodes for field connections. The field connection materials supplied by the contractor shall be in adequate quantity to avoid delay in erection.

e) Furnish shop painting of all fabricated steelwork as per requirements of this Specification.

f) Suitably mark, bundle and pack for transport all fabricated materials.

g) Prepare and furnish detailed Bill of Materials, Drawing Office Despatch lists, Bolt List and any other list of bought out items

required in connection with the fabrication and erection of the structural steelwork.

h) Insure, load and transport all fabricated steelwork field connection materials to site.

2.2.0 **Work by others**

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

2.3.0 **Codes and standards**

All work under this specification shall, unless otherwise specified in the contract, conform to the requirements of the latest revision and/or replacements of the following or any other relevant Indian Standard specifications and codes of practice. In case any particular aspect of the work is not specifically covered by any Indian Standard Specification, any other standard practice, as may be specified by the Engineer shall be followed:-

**LIST OF I.S. CODES - RELEVANT TO FABRICATION OF STRUCTURAL STEEL WORK**

| **IS Codes** | | **Description** |
|---|---|---|
| IS : 800 | - | Code of practice for general construction in steel. |
| IS : 801 | - | Code of practice for use of cold formed light gauge steel structural members in general building construction. |
| IS : 806 | - | Code of practice for use of steel tubes in general building construction. |
| IS : 808 | - | Dimensions for rolled steel beams, channels and angle sections. |
| IS : 812 | - | Glossary of terms relating to welding & cutting of metals. |
| IS : 813 | - | Scheme of symbols for welding. |
| IS : 814 | - | Covered electrodes for metal arc welding of carbon and carbon manganese steel. |
| IS : 815 | - | Classification coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel. |

| | | |
|---|---|---|
| IS : 816 | - | Code of practice for use of metal arc welding for general construction in mild steel. |
| IS : 817 | - | Code of practice for training & testing metal arc welders. |
| IS : 818 | - | Code of practice for safety and health requirements in electric and gas welding and cutting operations. |
| IS : 819 | - | Code of practice for resistance spot welding for light assemblies in mild steel. |
| IS : 822 | - | Code of practice for inspection of welds. |
| IS : 919 (Part - 1&2) | - | Recommendations for limits and fits for engineering. |
| IS : 1161 | - | Steel Tubes for structural purposes. |
| IS : 1182 | - | Recommended practice for Radiographic Examination of fushion welded butt joints in steel plates. |
| IS : 1200 (Part - 8) | - | Method of measurement of steel work and iron work |
| IS : 1239 (Part - 1&2) | - | Mild steel tubes, tubulars and other wrought steel fittings |
| IS : 1363 (Part - 1 to 3) | - | Hexagon head bolts, screws and nuts of product grade C. |
| IS : 1364 (Part - 1 to 5) | - | Hexagon head bolts, screws and nuts of product grade A & B. |
| IS : 1365 | - | Slotted counter sunk head screws (dia. 1.6 to 20 mm) |
| IS : 1367 (Part - 1 to 18) | - | Technical supply conditions for threaded steel fasteners. |
| IS : 1608 | - | Method for tensile testing of steel products. |
| IS : 1730 | - | Dimensions for steel plate, sheet and strip for structural and general engineering purposes. |

| | | |
|---|---|---|
| IS : 1852 | - | Rolling and cutting tolerances for hot-rolled steel product. |
| IS : 1977 | - | Structural steel (Ordinary quality) |
| IS : 2016 | - | Plain washer |
| IS : 2062 | - | Steel for general structural purposes. |
| IS : 2629 | - | Recommended practice for hot-dip galvanising of iron and steel. |
| IS : 2633 | - | Method for testing uniformity of coating on zinc coated articles. |
| IS : 3644 | - | Code of practice for ultrasonic pulse echo testing by contact and immersion method. |
| IS : 3757 | - | High Strength Structural Bolt |
| IS : 4000 | - | High strength bolts in steel structure |
| IS : 4759 | - | Specifications for hot-dip zinc coatings on structural steel and other allied products. |
| IS : 4923 | - | Hollow steel sections for structural use. |
| IS : 5334 | - | Code of practice for magnetic particle flaw detection of weld. |
| IS : 5369 | - | General requirements for plain washers and lock washer. |
| IS : 6005 | - | Code of practice for phosphating of iron and steel. |
| IS : 6649 | - | Specification for hardened and tempered washers for high strength structural bolts and nuts. |
| IS : 6623 | - | Specification for high strength structural nuts. |
| IS : 7215 | - | Tolerances for fabrication of steel structures. |
| IS : 7280 | - | Bare wire electrode for submerged arc welding. |
| IS : 8500 | - | Structural steel micro alloyed (medium & high strength quality). |
| IS : 8629 | - | Code of practice for protection of iron and (Part - I to III) steel structures from atmospheric corrosion. |
| IS : 9595 | - | Recommendation for metal arc welding of carbon manganese steels. |

**PAINTING**

| | | |
|---|---|---|
| IS : 117 | - | Specification for ready mixed paint, brushing, finishing, exterior, semi-gloss, for general purposes. |
| IS : 128 | - | Specification for ready mixed paint, brushing, finishing, semi-gloss for general purposes, black. |
| IS : 1477 (Part - I & II) | - | Code of practice for painting of ferrons metal in building. |
| IS : 2074 | - | Ready mixed paint, air-drying red-oxide zinc chrome priming. |
| IS : 2339 | - | Specification for aluminium paints for general purposes in dual container. |
| IS : 2932 | - | Specification for enamel, synthetic exterior type - I. |
| IS : 2933 | - | Specification for enamel, synthetic exterior type - II. |

2.4.0 **Conformity with Designs**

The contractor shall design all connections, supply and fabricate all steelwork and furnish all connection materials in accordance with the approved 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.

2.5.0 **Materials to be used**

2.5.1 **General**

All steel materials shall be free from all imperfections, mill scales, slag intrusions, laminations, pittings, 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 of materials supplied by the contractor 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 tonnes or less of any particular section.

The arc welding electrodes shall conform 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 ampereage ( Polarity in case of D.C. supply ) for which the electrodes are suitable.

2.5.2 **Steel**

All steel materials to be used in construction within the purview of this specification shall comply with any of the following Indian Standard Specifications as may be applicable :

1) IS : 801 - Cold formed light gauge steel structural member.

2) IS : 806 - Steel tubes in general building construction.

3) IS : 1161 - Steel tubes for structural purpose.

4) IS : 1977 - St-42-0 Structural steel (Ordinary quality)

5) IS : 2062 - Steel for general structural purpose

6) IS : 8500 - Structural steel-microalloyed (Ordinary & high strength quality)

In case of imported steel materials being used, these shall conform to specifications equivalent to any of the above as may be applicable.

2.5.3 **Electrodes**

All electrodes to be used under the Contract shall comply with any of the following Indian Standard Specifications as may be applicable :

1) IS : 814 - Covered electrodes for metal arc welding structural steel

2) IS : 815 - Classification and coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel.

3) IS : 7280 - Base wire electrode for submerged arc welding.

2.5.4 **Bolts and Nuts**

All bolts and nuts shall conform to the requirements of Indian Standard Specification IS:1367 - Technical Supply Conditions for Threaded Fasteners.

Materials for Bolts and nuts under the purview of this contract shall comply with any of the following Indian Standard Specifications as may be applicable.

a) Mild Steel : All mild steel for bolts and nuts when tested in accordance with the following Indian Standard Specification shall have a tensile strength of not less

than 44 Kg/mm$^2$ and a minimum elongation of 23 per cent on a gauge length of 5.6 /A, where 'A' is the cross sectional area of the test specimen : -

1) IS:1367 - Technical supply conditions for threaded fasteners.

2) IS:1608 - Method for tensile testing of steel other than sheet, strip, wire and tube.

b) High Tensile Steel : The material used for the manufacture of high tensile steel bolts and nuts shall have the mechanical properties appropriate to the particular class of steel as set out in IS:1367 or as approved by the Engineer.

2.5.5 **Washers**

Washers shall be made of steel conforming to any of the following Indian Standard Specifications as may be applicable under the provisions of the Contract :

1) IS : 1977 - Structural steel (Ordinary Quality) St-42-0

2) IS : 2062 - Steel for general structural purpose

3) IS : 8500 - Structural steel - microalloyed (medium & high strength quality)

4) IS : 6623 - High Strength Structural Nuts

5) IS : 6649 - Hardened and tampered washers for high strength structural bolts & nuts.

2.5.6 **Paints**

Paints to be used for shop coat of fabricated steel under the purview of this contract shall conform to the Indian Standard Specification IS:2074 - Ready mixed Paint, Air Drying, Red Oxide - Zinc Chromate Priming.

In highly corrosive environment other type of primer such as epoxy resin based zinc rich primer (such as blast steel EZ1 of Shalimer Paints Ltd., may be necessary.

2.6.0 **Storage of Material**

2.6.1 **General**

All materials shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged shall be removed from the contractor's yard immediately, failing which, the Engineer shall be at liberty to get the material removed. The Contractor shall maintain upto date

accounts in respect of receipt, use and balance of all sizes and sections of steel and other materials. In case the fabrication is carried out in contractor's fabrication shop outside the plant site where other fabrication works are also carried out, all materials meant for use in this contract shall be stacked separately with easily identifiable marks.

2.6.2 **Steel**

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

2.6.3 **Electrodes**

The electrodes for electric are 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.

2.6.4 **Bolts, Nuts and Washers**

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.

2.6.5 **Paints**

Paints shall be stored under cover in air tight containers. Paints supplied in sealed containers shall be used up as soon as possible once the container is opened.

2.7.0 **Quality Control**

The Contractor shall establish and maintain quality control procedures for different items of work and materials to the extent he deems necessary to ensure that all work is performed in accordance with this specification. In addition to the Contractor's quality control procedures, materials and workmanship at all times shall be subjected to inspection by the Engineer or Engineer's representative. As far as possible, all inspection by the Engineer or Engineer's representative shall be made at the Contractor's fabrication shop whether located at Site or elsewhere. The Contractor shall co-operate with the Engineer or Engineer's representative in permitting access for inspection to all places where work is being done and in providing all necessary help in respect of tools and plants, instrument, labour and materials required to carry out the inspection. The inspection shall be so scheduled as to provide the minimum interruption to the work of the Contractor.

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.

The quality control procedure shall cover but not be limited to the following items of work :

1) Steel : Quality, manufacturer's test certificates, test reports of representative samples of materials from unidentified stocks if permitted to be used.

2) Bolts, Nuts & Washers : Manufacturer's certificate, dimension checks, material testing.

3) Electrodes : Manufacturer's certificate, thickness and quality of flux coating.

4) Welders : Qualifying Tests

5) Welding sets : Performance Tests

6) Welds : Inspection, X-ray, Ultrasonic tests

7) Paints : Manufacturer's certificate, physical inspection reports

8) Galvanizing : Tests in accordance with IS : 2633 - Method for testing uniformity of coating on Zinc Coated Articles and IS : 4759 - Specification for Hot-Dip Zinc coatings on Structural Steel and other allied products.

2.8.0 **Standard dimensions, forms and weights**

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.

2.9.0 **Shop Drawings**

The Contractor shall submit to the Engineer the Schedule of Fabrication and delivery of structural steelwork for approval. He shall start to submit progressively for approval the shop drawings based on the approved Design Drawings and before proceeding with the fabrication work, shall get the said shop drawings approved in accordance with the contract.

The sequence of submission of shop drawings for approval shall match with the approved fabrication and delivery schedule. The approval for the shop drawings will be accorded only towards the general conformity with the design requirements as well as specification and will ensure the correctness

of general arrangement for centreline dimensions and levels, Section sizes, and adequacy of connections including splice joints as to the no. of bolts, weld length, size of gusset/end plates.

The correctness of all other details like cutting lengths, matching of holes, notch dimensions, match markings, bill of materials, bolt list etc. will be entirely the contractor's responsibility. The approval of the drawing however shall not relieve the contractor of his sole responsibility in carrying out the work correctly and fulfilling the complete requirements of contract documents.

The shop drawings shall include but not be 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 bolt location etc.

c) Details of all connections with supporting calculations.

d) Comparison sheets to show that the proposed alternative section, if any, are as strong as the original sections shown on the Design Drawings.

e) Complete Bill of Materials and detailed drawings of all sections as also their billing weights.

f) Any other drawings or calculations that may be required for the clarification of the works or substituted parts thereof.

The shop drawings shall give all the necessary information for the fabrication, erection and painting of the steelwork in accordance with the provisions of this Specification. Shop drawings shall be made in accordance with the best modern practice and with due regard to sequence, speed and economy in fabrication and erection. Shop drawings shall give complete information necessary for fabrication of various components of the steelwork, including the location, type, size and extent of welds. These shall also clearly distinguish between shop and field bolts and welds and specify the class of bolts and nuts. The drawings shall be drawn to a scale large enough to convey all the necessary information adequately.
Notes on the shop drawings shall indicate those joints or groups of joints in which it is particularly important that the welding sequence and technique of welding shall be carefully controlled to minimize the locked -up stresses and distortion.

Welding symbols used shall be in accordance with the requirements of the Indian Standard Specification --IS:813 - Scheme of symbols for Welding, and shall be consistent throughout. Weld lengths called for on the drawings shall mean the net effective length.

The Contractor shall be responsible for and shall pay for any alterations of the work due to any discrepancies, errors or omissions on the drawings or

other particulars supplied by him, whether such drawings or other particulars have been duly approved or not in accordance with the Contract.

## 3.0.0 WORKMANSHIP

### 3.1.0 Fabrication

#### 3.1.1 General

All workmanship shall be equal to the best practice in modern structural shops, and shall conform to the provisions of the Indian Standard IS:800 - Code of Practice for use of Structural Steel in General Building Construction and other relevant Indian Standards.

#### 3.1.2 Straightening Material

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 IS:1852 - 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 Deg. C.

#### 3.1.3 Cutting

Cutting shall be effected by shearing, cropping or sawing. Use of a mechanically controlled gas cutting torch may be permitted for mild steel only. Gas cutting of high tensile steel may 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 gauges 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.

#### 3.1.4 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.

3.1.5 **Clearances**

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 without web cleats 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.

3.2.0 **Bolted construction**

3.2.1 **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 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 bolt is less or more than or equal to 25 mm ) larger in diameter than the nominal diameter of the black bolt passing through them.

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 H8 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 thicknesses 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 bolts shall not be formed by gas cutting process.

3.2.2 **Assembly**

Drifting to enlarge unmatching 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 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.

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 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 out 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.

3.3.0 **Welded Construction**

3.3.1 **General**

Welding shall be in accordance with relevant Indian Standards and as supplemented in the Specification. Welding shall be done by experienced and good welders who have been qualified by tests in accordance with IS:817.

3.3.2 **Preparation of Material**

Surface to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign material except that mill scale which withstands vigorous wire brushing may remain. Joint surfaces shall be free from fins and tears. Preparation of edges by gas-cutting shall, wherever practicable, be done by a mechanically guided torch.

3.3.3 **Assembling**

Parts to be fillet welded shall be brought in as close contact as practicable and in no event shall be separated by more than 4 mm. If the separation is 1.5 mm or greater, the size of the fillet welds shall be increased by the amount of the separation. The fit of joints at contact surfaces which are not completely sealed by welds, shall be close enough to exclude water after painting. Abutting parts to be butt-welded shall be carefully aligned. Misalignments greater than 3 mm shall be corrected and in making the correction the parts shall not be drawn into a sharper slope than two degrees (2 Deg.).

The work shall be positioned for flat welding whenever practicable.

3.3.4 **Welding Sequence**

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as will avoid needless distortion and minimize shrinkage stresses. Where it is impossible to avoid high residual stresses in the closing welds of a rigid assembly, such closing welds shall be made in compression elements.

In the fabrication of cover-plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the member. Long girders or girder sections may be made by shop splicing not more than three sub-sections, each made in accordance with this paragraph. When required by the Engineer, welded

assemblies shall be stress relieved by heat treating in accordance with the provisions of the relevant Indian Standard or any other Standard approved by the Engineer.

3.3.5 **Welding technique**

All complete penetration groove welds made by manual welding, except when produced with the aid of backing material not more than 8 mm thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged out on the back side before welding is started from that side, and shall be so welded as to secure sound metal and complete fusion throughout the entire cross-section. Groove welds made with the use of the backing of the same material as the base metal shall have the weld metal thoroughly fused with the backing material. Backing strips need not be removed. If required, they may be removed by gouging or gas cutting after welding is completed, provided no injury is done to the base metal and weld metal and the weld metal surface is left flush or slightly convex with full throat thickness.

Groove welds shall be terminated at the ends of a joint in a manner that will ensure their soundness. Where possible, this should be done by use of extension bars or run-off plates. Extension bars or run-off plates need not be removed upon completion of the weld unless otherwise specified elsewhere in the Contract.

To get the best and consistent quality of welding, automatic submerged arc process shall be preferred. The technique of welding employed, the appearance and quality of welds made, and the methods of correcting defective work shall all conform to the relevant Indian Standards.

3.3.6 **Temperature**

No welding shall normally be done on parent material at a temperature below (-) 5 Deg.C. However, if welding is to be undertaken at low temperature, adequate precautions as recommended in relevant Indian Standard shall be taken. When the parent material is less than 40 mm thick and the temperature is between (-) 5 Deg. C and 0 Deg. C, the surface around the joint to a distance of 100 mm or 4 times the thickness of the material, whichever is greater, shall be preheated till it is handwarm. When the parent material is more than 40 mm thick, the temperature of the area mentioned above shall be in no case be less than 20 Deg. C. All requirements regarding preheating of the parent material shall be in accordance with the relevant Indian Standard.

3.3.7 **Peening**

Where required, intermediate layers of multiple-layer welds may be peened with light blows from a power hammer, using a round-nose tool. Peening shall be done after the weld has cooled to a temperature warm to the hand. Care shall be exercised to prevent scaling or flaking of weld and base metal from over peening.

3.3.8 **Equipment**

These shall be capable of producing proper current so that the operator may produce satisfactory welds. The welding machine shall be of a type and

capacity as recommended by the manufacturers of electrodes or as may be approved by the engineer.

3.4.0 **Finish**

Column splices and butt joints of compression members depending on contact for stress transmission shall be accurately machined and close-butted over the whole section with a clearance not exceeding 0.2 mm locally at any place. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc., after welding together, should be accurately machined so that the parts connected butt over the entire surfaces of contact. Care should be taken that those connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 2.0 mm.

3.5.0 **Slab bases and caps**

Bases and caps fabricated out of steel slabs, except when cut from material with true surface, shall be accurately machined over the bearing surface and shall be in effective contact with the end of the stanchion. 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. To facilitate grouting, holes shall be provided, where necessary, in stanchion bases for the escape of air.

3.6.0 **Lacing bars**

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

3.7.0 **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.

3.8.0 **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.

3.9.0 **Architectural Clearances**

Bearing plates and stiffener connections shall not be permitted to encroach on the designed architectural clearances.

3.10.0 **Shop connections**

a) All shop connections shall be welded as specified on the Drawings.

b) Certain connections, specified to be shop connections, may be changed to field connections if desired by the Engineer for convenience of erection and the Contractor will have to make the desired changes.

3.11.0 **Castings**

Steel castings shall be annealed

3.12.0 **Shop erection**

The steelwork shall be temporarily shop-erected complete or as directed by the Engineer so that accuracy of fit may be checked before despatch. The parts shall be shop-erected with a sufficient number of parallel drifts to bring and keep the parts in place. In case of parts drilled or punched using steel jigs to make all similar parts interchangeable, the steelwork shall be shop erected in such a way as will faciliate the check of interchangeability.

3.13.0 **Shop painting**

3.13.1 **General**

Unless otherwise specified, steelwork which will be concealed by interior building finish need not be painted; steelwork to be encased in concrete shall not be painted. Unless specifically exempted, all other steelwork shall be given one coat of shop paint, applied thoroughly and evenly to dry surfaces which have been cleaned, in accordance with the following paragraph, by brush, spray, roller coating, flow-coating or dipping as may be approved by the Engineer.

After inspection and approval and before leaving the shop, all steelwork specified to be painted shall be cleaned by hand-wire brushing or by other mechanical cleaning methods to remove loose mill scale, loose rust, weld slag or flux deposit, dirt and other foreign matter. Oil and grease deposits shall be removed by solvent. Steelwork specified to have no shop paint shall, after fabrication, be cleaned of oil or grease by solvent cleaners and be cleaned of dirt and other foreign material by through sweeping with a fibre brush.

After completion of the precleaning, the metal surface shall immediately painted with red oxide zinc chromate primer conforming to IS : 2074.

In highly corrosive environment, all steelwork shall be given a coat of shop paint, applied thoroughly and evenly to dry surfaces which have been cleaned by sand blasting to SA 2/1/2 grade minimum. The shop paint shall be epoxy rasin based zinc rich primer such as Blast Steel EZ1 of Shalimer Paint Limited.

3.13.2 **Inaccessible parts**

Surfaces not in contact, but inaccessible after assembly, shall receive two coats of shop paint, positively of different colours to prove application of two coats before assembly. This does not apply to the interior of sealed hollow sections.

3.13.3 **Contact surfaces**

Contact surface shall be cleaned in accordance with Sub-clause 3.13.1 before assembly.

3.13.4 **Finished surfaces**

Machine finished surfaces shall be protected against corrosion by a rust inhibiting coating that can be easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.

3.13.5 **Surfaces adjacent to field welds**

Unless otherwise provided for, surfaces within 50 mm of any field weld location shall be free of materials that would prevent proper welding or produce objectionable fumes while welding is being done.

3.14.0 **Galvanizing**

3.14.1 **General**

Structural steelwork for switchyard or other structures as may be specified in the Contract shall be hot dip galvanized in accordance with the American Society for Testing and Materials Specification ASTM-A 123 or IS : 2629 - Recommended practice for Hot-Dip Galvanising of Iron and steel. Where the steel structures are required to be galvanized the field connection materials like bolts, nuts and washers shall also be galvanized.

3.14.2 **Surface Preparation**

All members to be galvanized shall be cleaned, by the process of pickling of rust, loose scale, dirt, oil, grease, slag and spatter of welded areas and other foreign substances prior to galvanizing. Pickling shall be carried out by immersing the steel in an acid bath containing either sulphuric or hydrochloric acid at a suitable concentration and temperature. The concentration of the acid and the temperature of the bath can be varied, provided that the pickling time is adjusted accordingly.

The pickling process shall be completed by thoroughly rinsing with water, which should preferably be warm, so as to remove the residual acid.

3.14.3 **Procedure**

Galvanizing shall be carried out by hot dip process in a proper and uniformly heated bath. It shall meet all the requirements when tested in accordance with IS:2633 - Method for testing uniformity of coating on Zinc Coated Articles and IS:4759 - Specification for Hot-dip zinc coatings on Structural Steel & other allied products.

After finishing the threads of bolts, galvanizing shall be applied over the entire surface uniformly. The threads of bolts shall not be machined after galvanizing and shall not be clogged with zinc. The threads of nuts may be tapped after galvanizing but care shall be taken to use oil in the threads of nuts during erection.

The surface preparation for galvanizing and the process of galvanizing itself, shall not adversely affect the mechanical properties of the materials to be galvanized. Where members are of such lengths as to prevent complete dipping in one operation, great care shall be taken to prevent warping.

Materials on which galvanizing has been damaged shall be acid stripped and re-galvanized unless otherwise directed, but if any member becomes damaged after having been dipped twice, it shall be rejected. Special care shall be taken not to injure the skin on galvanized surfaces during transport and handling. Damages, if occur, shall be made good in accordance with the provisions of this Specification or as directed by the Engineer.

## 4.0.0 INSPECTION, TESTING, ACCEPTANCE CRITERIA AND DELIVERY

### 4.1.0 Inspection

Unless specified otherwise, inspection to all work shall be made by the Engineer or Engineer's representative at the place of manufacture prior to delivery. The Engineer or his representative shall have free access at all reasonable times to those parts of the manufacturer's works which are concerned with the fabrication of the steelwork under this Contract and he shall be afforded all reasonable facilities for satisfying himself that the fabrication is being done in accordance with the provisions of this Specification.

The Contractor shall provide such labour, materials, electricity, fuel, water, stores, tools and plant, apparatus and instruments as may be required by the Engineer to carry out inspection and/or tests in accordance with the Contract.

The Contractor shall guarantee compliance with the provisions of this Specification.

### 4.2.0 Testing and Acceptance Criteria

4.2.1 **General**

The Contractor shall carry out sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost, unless otherwise specified in the Contract. The Contractor shall get the specimens tested in a laboratory approved by the Engineer and submit to the Engineer the test results in triplicate within 3 (three) days after completion of the test.

4.2.2 **Steel**

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.

All material shall be free from all imperfections, mill scales, slag intrusions, laminations, pittings, rusts etc. that may impair their strength, durability and appearance.

4.2.3 **Testing Criteria for checking Lamination in raw steel plates**

All raw steel plate of thickness more than 20 mm supplied by the contractor shall be checked against lamination before procurement & prior to commencement of fabrication work in the following ways as directed by the Engineer.

a) Ultrasonic testing along the edge of specified points of the plates shall be carried out to delete lamination in the plates, if any.

b) If the results of the tests in (a) are not satisfactory, the whole area of the plates shall be checked by ultrasonic testing at specified nodal points formed at equidistant grid locations. The spacing of the grids shall be determined from tests in (a) or as directed by the Engineer.

If the results of the above tests are not satisfactory, the plates shall not be taken up for fabrication work. Even after fabrication at shop, if the Engineer requires any ultrasonic testing to detect lamination of plates, the same shall be carried out by the Contractor. If the plates in the fabricated item is found to be laminated, the component will be rejected.

4.2.4 **Welding**

All electrodes shall be procured from reliable 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 tonnes of welded fabrication, the Engineer may ask for at least 1 (one) test-destructive or non-destructive including X-ray, ultrasonic test or similar. In the event of

further tests as may be desired by the Engineer, if the results are found to be unsatisfactory; and if the test shows no defect. In cases of the test results showing deficiency, the Engineer shall have option to reject or instruct any remedial measures to be taken.

4.2.5 **Bolts, nuts and washers**

All bolts, nuts and washers shall be procured from reputed manufacturer approved by the Engineer and shall conform 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.

4.2.6 **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.

4.2.7 **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 IS:4759 - specification for Hot-Dip Zinc Coatings on Structural Steel & other allied products.

4.3.0 **Tolerance**

The tolerances on the dimensions of individual rolled steel components shall be as specified in IS:1852 - specification for rolling and Cutting Tolerances for Hot-rolled Steel Products. The tolerances on straightness, length etc. of various fabricated components (such as beams and girders, columns, crane gantry girder etc.) of the steel structures other than steel railway & road bridges, structures subjected to dynamic loading (like wind, seismic etc.) and thin walled construction (like box girders) shall be as specified in IS:7215 - Tolerances for Fabrication of Steel Structures.

4.4.0 **Acceptance**

Should any structure or part of a structure be found not to comply with any of the provisions of this Specification, the same shall be liable to rejection. No structure or part of the structure, once rejected, shall be offered again for test, except in cases where the Engineer considers the defects rectifiable. The Engineer may, at his discretion, check the test results obtained at the Contractor's works by independent tests at an approved laboratory and should the items, so tested, be found to be unsatisfactory.

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 Engineer will issue an acceptance certificate,

upon receipt of which, the items will be shop painted, packed and despatched. 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.

## 4.5.0 Delivery of materials

### 4.5.1 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.

### 4.5.2 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.

### 4.5.3 Packing and Shipping

All projecting plates or edges and all ends of members of joints shall be stiffened, all straight members 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 order to prevent damage or distortion during shipping.

Shipping shall be strictly in accordance with the sequence stipulated in the agreed programme. Payment may be held up for items sent in advance of the sequence till they could be erected. The Contractor shall include and provide for in his rates, the freight and other charges for despatching the materials to the worksite and also for securely protecting and packing the materials to avoid loss or damage during transport by rail, road or water. All packings shall allow for easy removal and checking at site. Special precautions shall be taken against rusting, corrosion, breakage or damage otherwise of the materials. 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 : -

a) Name and address of the consignee

b) Name and address of the consignor

c) Gross weight of the package in tonnes and its dimensions

d) Identification marks and/or number of the package

e) 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 :

a) Name of the Contractor

b) Number and date of the Contract

c) Name of the office placing the contract

d) Nomenclature of stores

e) A schedule of parts or pieces, giving the parts or piece number with reference to assembly drawings and the quantity of each.

The shipping dimensions of each package 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 hereinbefore, any loss or damage resulting from inadequate packing shall be made good by the Contractor 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, wharfage, 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 progressive bills of the Contractor.

Necessary advise regarding the shipment with relevant details shall reach the Engineer at least a week in advance.

## 5.0.0 INFORMATION TO BE SUBMITTED

### 5.1.0 With Tender

The following information are required to be submitted with the Tender :

a) Progress Schedule

The Contractor shall quote in his Tender a detailed schedule of progress of work and total time of completion, itemizing the time required for each of the following aspects of work.

1) Preparation and approval of shop drawings

2) Procurement of materials

3) Fabrication and shipping of all anchor bolts

4) Fabrication and shipping of main steelwork

5) Fabrication and shipping of steelwork for bunkers. Tanks and/ or silos as applicable.

6) Fabrication and shipping of all other remaining steel work including miscellaneous steelwork

7) Final date of completion of all shipments

Time required for completion being one of the main criteria for selecting the successful bidder, it is desired that the bidder quotes the minimum time required by him for completing the work.

b) Shop

Location of the Tenderer's fabrication workshop giving details of equipment, manpower, the total capacity and the capacity that will be available exclusively for this contract shall be submitted.

c) Matching Steel

A rough indication of the quantities and details of matching steel sections required to start the work shall be furnished.

5.2.0 **After Award**

After award of the Contract the successful Tenderer is to submit the following :

a) Complete fabrication drawings, material lists, cutting lists, bolt lists, field welding schedules based on the design drawings in accordance with the approved schedule.

b) Monthly Progress Report with necessary photographs in six (6) copies to reach the Engineer on or before the 7th day of each month, giving the upto date status of preparation of detailed shop drawings, bill of materials, procurement of materials, actual fabrication done, shipping and all other relevant information.

c) Results of any test as and when conducted and as required by the Engineer.

d) Manufacturer's mill test report in respect of steel materials, bolts, nuts and electrodes as may be applicable.

# VOLUME – II B
## CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

## SPECIFICATION NO. PE-TS-411-620-C001

## SECTION - D

## *GENERAL TECHNICAL SPECIFICATION*

## ERECTION OF STRUCTURAL STEELWORK

**Bharat Heavy Electricals Limited**
**Project Engineering Management**
**PPEI Building, Power Sector,**
**Plot No. 25, Sector 16A,**
**Noida (U.P.)-201301**

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**FOR**
**ERECTION OF STRUCTURAL STEELWORK**

## 1.0.0 SCOPE

This specification covers the erection of structural steelwork including receiving and taking delivery of fabricated structural steel materials arriving at Site and installing the same in position, painting and grouting the stanchion bases all complete as per Drawings, this Specification and other provision of the Contract.

## 2.0.0 GENERAL

### 2.1.0 Work to be provided for by the Contractor

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

a) The Contractor shall provide all construction and transport equipment, tools, tackle, consumables, materials, labour and supervision required for the erection of the structural steelwork.

b) 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.

c) Transportation of all fabricated structural steel materials from Site storage yard, handling, rigging, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and/or as directed by the Engineer. If necessary suitable temporary approach roads to be built for transportation of fabricated steel structures.

d) 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 brought to the notice of the Engineer. The Contractor shall fully satisfy himself regarding the correctness of the foundations before installing the fabricated steel structures on the foundation blocks.

e) Aligning, plumbing, levelling, bolting, welding and securely fixing the fabricated steel structures in accordance with the Drawings or as directed by the Engineer.

f) Painting of the erected steel structures if required by the Contract.

g) 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 bolt if required.

iv) Welding of connections in place of bolting for which holes are either not drilled at all or wrongly drilled during fabrication. Welding in place of bolting will be permitted only at the discretion of the Engineer.

v) Refabrication of parts damaged beyond repair during transport and handling or Refabrication of parts which are incorrectly fabricated.

vi) Fabrication of parts omitted during fabrication by error, or subsequently found necessary.

vii) Drilling of holes which are either not drilled at all or are drilled in incorrect location during fabrication.

viii) Carry out tests in accordance with this Specification if directed.

2.2.0 **Work by others**

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

2.3.0 **Codes and Standards**

All work under this Specification shall, unless specified otherwise, conform to the latest revisions and/or replacements of the following or any other Indian Standard Specification and codes of Practice of equivalent:-

IS-800 : Code of Practice for general construction in steel

IS-456 : Code of Practice for plain or reinforced concrete

IS-7205 : Safety Code for erection of Structural Steel work

IS-12843 : Tolerance for erection of Steel Structures

2.4.0 **Conformity with designs**

The Contractor will 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 design criteria detailed in the approved erection drawings and/or other stated document. All work shall conform to the provisions of the relevant Indian Standard

Specifications and/or the 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.

2.5.0 **Material**

2.5.1 **General**

The Contractor will check the quantity, quality and the sizes of the fabricated materials and verify the adequacy of the same in accordance with the Drawings and Specifications. The Contractor shall make good any deficiency, if detected, either by repair or with fresh material as may be directed by the Engineer.

All consumables like oxygen and acetylene gas, paints, fuels, lubricants, oil, grease, cement, sand, aggregates and any other material that may be required for the execution of the works in accordance with the contract will be supplied by the contractor for erection work and will be deemed to have been included in this rates.

2.5.2 **Materials to conform to Indian Standards**

All materials required to be supplied by the Contractor under this Contract shall conform to the relevant Indian Standard Specifications.

2.6.0 **Storage of materials**

2.6.1 **General**

All material shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for use in the works. Any material which has been deteriorated or damaged beyond repairs and has become unfit for use shall be removed immediately from the site, failing which, the Engineer shall be at liberty to get the materials removed by agency.

2.6.2 **Yard**

The Contractor will have to establish a suitable yard in an approved location at site for storing the fabricated steel structures and other materials which will be delivered to him by the Owner according to the Contract. The yard shall have proper facilities like, drainage, lighting, 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 Tenderer should visit the site prior to submission of his Tender to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc. all of which shall be carried out by the Contractor as directed by the Engineer.

2.6.3 **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.

2.7.0 **Quality Control**

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:-

1) Erection : Lines, levels, grades, plumbs, joint characteristics including tightness of bolts.

2) Grouting : Cleaning and roughness of foundation, quality of materials used for grouting, admixtures, consistency and strength of grout.

3) Painting : Preparation of surface for painting, quality of primers and paints, thinners, application and uniformity of coats.

The Contractor shall salvage, collect and deliver all the packing materials to the Owner.

3.0.0 **WORKMANSHIP**

3.1.0 **Erection**

3.1.1 **Plant and equipment**

The suitability and adequacy of all erection tools and plant and equipment proposed to be used shall be efficient, dependable, in good working condition and shall have the approval of the Engineer.

3.1.2 **Method and sequence of erection**

The method and sequence of erection shall have the prior approval of the Engineer. The Erection shall arrange for most economical method and sequence available to him consistent with the Drawings and Specifications and such information as may be furnished to him prior to the execution of the Contract.

3.1.3 **Temporary bracing**

Unless adequate bracing is included as a part of the permanent framing, the erector during erection shall install temporary guys and bracings where needed to secure the framing against loads such as wind or seismic forces comparable in intensity to that for which the structure has been designed, acting upon exposed framing as well as loads due to erection equipment and erection operations.

If additional temporary guys are required to resist wind or seismic forces acting upon components of the finished structure installed by others during the course of the erection of the steel framing, arrangement for their installation by the erector shall be made.

The responsibility of the Contractor in respect of temporary bracings and guys shall cease when the structural steel is once located, plumbed, levelled, aligned and grouted within the tolerances permitted under the specification and guyed and braced to the satisfaction of the Engineer.

3.1.4 **Temporary floors for buildings**

It shall be the responsibility of the Contractor to provide free of cost planking and to cover such floors during the work in progress as may be required by any Act of Parliament and/or by-laws of state, Municipal or other local authorities.

3.1.5 **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 approved Drawings and to the satisfaction of the Engineer. Concrete foundations, where required, shall be made by other agencies. Anchor bolts and other anchor steel shall be embedded by other agencies. The Contractor shall check the positions and levels of the anchor bolts, etc. before concreting and get them properly secured against disturbance during pouring operations. He shall remain responsible for correct positioning. For heavy columns, etc. the Contractor shall set proper screed bars if desired by the Engineer, to maintain proper level.

Each tier of column shall be plumbed and maintained in a true vertical position subject to the limits of tolerance allowable under this Specification.

No permanent field connections by bolting or welding shall be carried out until proper alignment and plumbing has been attained.

3.1.6 **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.

a) **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 nut rotation specified in Table-1 with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of the part not turned by the wrench.

**TABLE - I**

| Bolts length not exceeding 8 x dia. or 200 mm | Bolt length exceeding 8xdia. or 200 mm | Remarks |
|---|---|---|
| 1/2 turn | 2/3 turn | Nut rotation is relative to bolt regardless of the element (nut or bolt) being tur-ned. 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 nut match-marked with the protruding bolt point before final tightening, thus affording the inspector visual means of noting the actual nut rotation. Such marks can be made by the wrench operator by suitable means after the bolts have been brought up snug tight.

b) **Torque Wrench tightening**

When torque wrenches are used to provide the bolt tensions, the bolts shall be tightened to the torques specified in TABLE - II. Nuts shall be in tightening motion when torque is measured. When using torque wrenches to install several bolts in a single joint, the wrench shall be returned to touch up bolts previously tightened, which may have been loosened by the tightening of subsequent bolts, until all are tightened to the required tension.

**TABLE - II**

| Nominal Bolt Diameter (mm) | Torque to be applied (Kg.M) for bolt class 8.8 of IS : 1367 |
|---|---|
| 20 | 59.94 |
| 22 | 81.63 |
| 24 | 103.73 |

**NOTE :**

The above torque values are approximate for providing tensions of 14.7 MT for 20 mm dia., 18.2 MT for 22 mm dia; and 21.2 MT 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 torque 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.

3.1.7 **Field Welding**

All field assembly and welding shall be carried out in accordance with the requirements of the specification for fabrication work applicable to the project, excepting such provisions therein which manifestly apply to shop conditions only. Where the fabricated structural steel members have been delivered painted, the paint shall be removed before field welding for a distance of at least 50 mm on either side of the joints.

3.1.8 **Holes, cutting and fitting**

No cutting of sections, flanges, webs, cleats, bolts, welds etc. shall be done unless specifically approved and/or instructed by the Engineer.

The erector shall not cut, drill or otherwise alter the work of other trades, or his own work to accommodate other trades, unless such work is clearly specified in the Contract or directed by the Engineer. Wherever such work is specified the Contractor shall obtain complete information as to size, location and number of alterations prior to carrying out any work.

3.2.0 **Drifting**

Correction of minor misfits and reasonable amount of reaming and cutting of excess stock from rivets will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to enlarge holes as necessary to make connections. Reaming, that weakens the member or makes it impossible to fill the holes properly or to adjust accurately after reaming shall not be allowed.

Any error in shop work which prevents the proper assembling and fitting of parts by moderate use of drift pins and reamers shall immediately be called to the attention of the Engineer and approval of the method of correction obtained. The use of gas cutting torches at erection site is prohibited.

3.3.0 Grouting of stanchion bases and bearings of beams and girders on stone, brick or concrete (Plain or reinforced)

Grouting shall be carried out with Ordinary Cement grout as described below :

The mix shall be one (1) part cement and one (1) part sand and just enough water to make it workable. The positions to be grouted shall be cleaned thoroughly with compressed air jet and wetted with water and any accumulated water shall be removed. These shall be placed under expert supervision, taking care to avoid air-locks. Edges shall be finished properly. If the thickness of grout is 25 mm or more, two (2) parts of 6 mm down graded stone chips may be added to the above noted cement-sand grout mix, if required, by the Engineer or shown on the drawings.

Admixtures like aluminium powder, "ironite" may be required to be added to the grout to enhance certain desirable properties of the grout.

Alternatively, the grouting may be done with non-shrink high strength free flow cementious grout (ready mixed) like “Sika grout - 214", or "Anchor NSG" or approved equivalent.

No grouting shall be carried out until a sufficient number of bottom lengths of stanchions have been properly lined, levelled and plumbed and sufficient floor beams are tied in position.

Whatever method of grouting is employed, the operation shall not be carried out until the steelwork has been finally levelled and plumbed, the stanchion bases being supported meanwhile by steel wedges, and immediately before grouting, the space under steel shall be thoroughly cleaned.

3.4.0 **Painting after erection**

Field painting, if required to be done by the erection Contractor, shall only be done after the structure is erected, levelled, plumbed, aligned and grouted in its final position, tested and accepted by the Engineer. However, touch up paintings, making good any damaged shop painting and completing any unfinished portion of the shop coat shall be carried out by the erection Contractor to the Owner. The materials and specification for such painting in the field shall be in accordance with the requirements of the specification for fabrication of structural steelwork applicable for the project.

Painting shall not be done in rainy or foggy weather or when humidity is such as to cause condensation on the surfaces to be painted. Before painting of steel, which is delivered unpainted, is commenced, all surfaces to be painted shall be dried and thoroughly cleaned from all loose scale and rust.

All field bolts, welds and abrasions to the shop coat shall be spot painted with the same paint used for the shop coat. Where specified, surfaces which will be in contact after site assembling shall receive a coat of paint (in addition to the shop coat, if any) and shall be brought together while the paint is still wet.

Surface which will be inaccessible after field assembly shall receive the full specified protective treatment before assembly. Bolts and fabricated steel members which are galvanized or otherwise treated and steel members to be encased in concrete shall not be painted.

The specification for paint and workmanship shall be in accordance with the requirements of the specification for fabrication of structural steelwork applicable to the project.

The number of coats and the shades to be used shall be as specified or as directed by the Engineer.

3.5.0 **Stainless Steel Plate Lining in Bunker Hopper**

The hopper portion of the coal bunkers shall be lined with stainless steel plates of 3 mm thickness. The stainless steel shall be of AISI-316 quality. The work includes supply, fabrication, welding and fixing of stainless steel lining plate to bunker M.S. plate as per drawing.

The stainless steel liner shall be fixed to the Bunker hopper by plug welding using special electrodes (such as, Inox-CW coding AWS-310-16 ISMBOS-311 or Inox-D2 coding AWSE-309-16, ISMB 04-311 manufactured by Advani Oerlikon Ltd). Such plug welding shall be done by drilling 21.5 mm dia. holes at 300 mm centre to centre both ways. The plug welding shall be ground flush with the lining plate.

3.6.0 **Final cleaning up**

Upon completion of erection and before final acceptance of the work by the Engineer, the Contractor shall remove all falsework, rubbish and all Temporary Works resulting in connection with the performance of his work.

3.7.0 **Safety Measures during Erection**

The safety measures to workmen and supervisors during all types of erection work (e.g., use of lifting appliances, slingning, welding, gas cutting, etc.) should be taken as per IS : 7205. When any statutory provisions exist, the same shall be complied with in addition to the provisions contained in the above code.

## 4.0.0 TESTING AND ACCEPTANCE CRITERIA

### 4.1.0 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. 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 by the Contractor responsible, to the satisfaction of the Engineer.

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 Sub-clauses 4.1.1, 4.1.2 and 4.1.3. The method of testing and application of loading shall be as approved by the Engineer.

### 4.1.1 Stiffness Test

In this test, the structure or member shall be subjected, in addition to its actual dead load, to a test load equal to1.5 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 second test is not less than 90 percent of the maximum increase in strain or deflection recorded during the second test.

### 4.1.2 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 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.

4.1.3 **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.

4.1.4 **Repair for subsequent test and use after strength tests**

An actual structure which has passed the "Strength Test" as specified in Sub-clause 4.1.2 hereinbefore 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' as specified in Sub-clause 4.1.1. hereinbefore.

4.2.0 **Tolerances**

Some variation is to be expected in the finished dimensions of structural steel frames. Unless otherwise specified, such variations are deemed to be within the limits of good practice when they are not in excess of the cumulative effect of detailed erection clearances, fabricating tolerances for the finished parts and the rolling tolerances for the profile dimensions permitted under the Specifications for fabrication of structural steelwork applicable to this Project and as specified below :

I. **For Buildings Containing Cranes**

| Component | Description | Variation Allowed |
|---|---|---|
| Main columns | a) Shifting of column axis at foundation level with respect to building line | |

| | | | |
|---|---|---|---|
| | | i) In longitudinal direction | i) ± 3.0 mm |
| | | ii) In lateral direction | ii) ± 3.0 mm |
| | | b) Deviation of both major column axis from vertical between foundation and other member connection levels : | |
| | | i) For a column upto and including 10M height | i) ± 3.5 mm from true vertical |
| | | ii) For a column greater than 10M but less than 40M height | ii) ± 3.5 mm from true vertical for any 10M length measured between connection levels, but not more than ± 7.0 mm per 30 m length. |

| **Component** | **Description** | **Variation Allowed** |
|---|---|---|
| | c) For adjacent pairs of columns across the width of the building prior to placing of truss. | ± 9 mm on true span. |
| | d) For any individual column deviation of any bearing or resting level from levels shown on drawings. | ± 3.0 mm |
| | e) For adjacent pairs of columns either across the width of building or longitudinally level difference allowed between bearing or seating level supposed to be at the same level. | 3 mm |
| Trusses | a) Deviation at centre of span of upper chord member from vertical plane running through centre of bottom chord. | 1/1500 of the span or not greater than 10 mm whichever is the least. |

| | | | |
|---|---|---|---|
| | | b) Lateral displacement of top chord at centre of span from vertical plane running through centre of supports. | 1/250 of depth of truss or 20 mm whichever is the least. |
| | Crane Girders & Tracks | a) Difference in levels of crane rail measured between adjacent columns. | 2.0 mm |
| | | b) Deviation to crane rail gauge | ± 3.0 mm |
| | | c) Relative shifting of ends of adjacent crane rail in plan and elevation after thermit welding. | 1.0 mm |
| | | d) Deviation of crane rail axis from centre line of web. | ± 3.5 mm |

| Component | Description | Variation Allowed |
|---|---|---|
| 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. | |

II. For Building without Cranes

The maximum tolerances for line and level of the steel work shall be ± 3.0 mm on any part of the structure. The structure shall not be out of plumb more than 3.5 mm on each 10M section of height and not more than 7.0 mm per 30 M section.

These tolerances shall apply to all parts of the structure unless the drawings issued for erection purposes state otherwise.

4.3.0 **Acceptance**

Structures and members which have passed the tests and conform to all requirements specified in the foregoing Sub-clause 4.1.0, 4.1.1, 4.1.2, 4.1.3 and 4.1.4 and other applicable provisions of this Specification and are within the limits of tolerances specified in Sub-clause 4.2.0 and/or

otherwise approved by the Engineer shall be treated as approved and accepted for the purpose of fulfilment of the provisions of this Contract.

## 5.0.0 INFORMATION TO BE SUBMITTED

### 5.1.0 Before Tender

Along with the Tenders the Tenderers will be required to submit the following information :

### 5.1.1 Tentative Programme

The Tenderer shall submit a tentative programme based on the information available in the Tender Document and visit to Site indicating the structure-wise erection schedule proposed to be maintained by the Contractor to complete the job in time in accordance with the Contract.

### 5.1.2 Constructional Plant and Equipment, Tools, Temporary Works & Manpower

A detailed list of all Constructional Plant & Equipment like cranes, derricks, winches, welding sets, erection tools etc. along with their make, model, present condition and location available with the Tenderer which he will be able to employ on the job to maintain the progress of work in accordance with the Contract shall be submitted along with the Tender. The total number of each category of experienced personnel like fitters, welders, riggers etc. that he will be able to employ on the job shall also be indicated.

### 5.1.3 Erection yard

A site plan showing the layout and location of the erection yard proposed to be established by the Tenderer shall be attached with the Tender indicating the storage space for fabricated steel materials, site-fabrication and repair shop, covered stores, offices, locations of erection equipments and other facilities. The Engineer shall have the right to modify the arrangement and location of the proposed yard to suit site conditions and the Contractor shall comply with the same without any claim whatsoever.

### 5.2.0 After award of the Contract

After award of the contract, the Contractor shall submit the following :-

### 5.2.1 Detailed Programme

The Contractor shall submit a detailed erection programme for completion of the work in time in accordance with the Contract. This will show the target programme, with details of erection proposed to be carried out in each fortnight, details of major equipment required and an assessment of

required strength of various categories of workers in a proforma approved by the Engineer.

5.2.2 **Fortnightly Progress Report**

The Contractor shall submit fortnightly progress reports in triplicate to the Engineer showing along with necessary photographs, 125 mm x 90 mm size, and all details of actual achievements against the target programme specified in Sub-clause 5.2.1 above. Any shortfall in the achievement in a particular fortnight must be made up within the next fortnight. Along with this report, the Contractor shall also furnish details of fabricated materials in hand at site and the strength of his workers.

# VOLUME – II B
## CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

## SPECIFICATION NO. PE-TS-411-620-C001

## SECTION - D

## *GENERAL TECHNICAL SPECIFICATION*

## FINISH TO MASONRY & CONCRETE

**Bharat Heavy Electricals Limited**
**Project Engineering Management**
**PPEI Building, Power Sector,**
**Plot No. 25, Sector 16A,**
**Noida (U.P.)-201301**

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# TECHNICAL SPECIFICATION FOR FINISH TO MASONRY & CONCRETE

## 1.0.0 SCOPE

This Specification covers furnishing, installation, repairing, finishing, curing, testing, protection, maintenance till handing over of finishing items for masonry and concrete. This shall also include the work to be done to make the surface suitable for receiving the finishing treatment. Before commencing finishing items the Contractor shall obtain the approval of the Engineer regarding the scheduling of work to minimise damage by other trades. He shall also undertake normal precaution to prevent damage or disfiguration to work of other trades or other installation.

## 2.0.0 INSTALLATION

### 2.1.0 Preparation of Surface

All joints in masonry walls shall be raked out to a depth of at least 10 mm with a hooked tool made for the purpose while the mortar is still green. Walls shall be brushed down with stiff wire brush to remove all loose dust from joints and thoroughly washed with water. All laitance shall be removed from concrete to be plastered.

For all types of flooring, skirting and dado work, the base cement concrete slab or masonry surface shall be roughened by chipping and cleaned of all dirt, grease or loose particles by hard brush and water. The surface shall be thoroughly moist to prevent absorption of water from the base course. Any excess of water shall be mopped up.

At any point, the level of base shall be lower than the theoretical finished floor level by the thickness of floor finish. Any chipping or filling to be done to bring the base in the required level shall be brought to the notice of the Engineer and his approval shall be taken regarding the method and extent of rectification work required.

Prior to commencement of actual finishing work, the approval or the Engineer shall be taken as to the acceptability of the base.

### 2.2.0 Plastering

#### 2.2.1 Mortar

Mortar for plastering shall be as specified in the drawings.

For sand cement plaster, sand and cement in the specified proportion shall be mixed dry on a watertight platform and minimum water added to achieve working consistency.

For lime gauged plaster, lime putty or hydrated lime and sand in the required proportion shall be mixed on a watertight platform with necessary addition of water and thoroughly ground in mortar mill. This mix shall then be transferred to a mechanical mixer to which the required quantity of cement is added and mixed for at least 3 minutes.

No plaster which has stood for more than half an hour shall be used; plaster that shows tendency to become dry before this time, shall have water added to it.

2.2.2 **Application of Plaster**

Plaster, when more than 12 mm thick, shall be applied in two coats - a base coat followed by the finishing coat. Thickness of the base coat shall be sufficient to fill up all unevenness in the surface; no single coat, however, shall exceed 12 mm in thickness. The lower coat shall be thicker than the upper coat, the overall thickness of the coats shall not be less than the minimum thick-ness shown on the drawings. The undercoat shall be allowed to dry and shrink before applying the second coat of plaster. The under-coat shall be scratched or roughened before it is fully hardened to form a mechanical key. The method of application shall be 'thrown on' rather than 'applied by trowel'.

To ensure even thickness and true surface, patches of plaster about 100 mm to 150 mm square or wooden screed 75 mm wide and of the thickness of the plaster, shall be fixed vertically about 2000 mm to 3000 mm apart, to act as gauges. The finished wall surface shall be true to plumb, and the Contractor shall make up any irregularity in the brickwork with plaster.

All vertical edges of brick pillars, doorjambs etc. shall be chamfered or rounded off as directed by the Engineer. All drips, grooves, mouldings and cornices as shown on drawing or instructed by the Engineer shall be done with special care to maintain true lines, levels and profiles. After the plastering work is completed, all debris shall be removed and the area left clean. Any plastering that is damaged shall be repaired and left in good condition at the completion of the job.

2.2.3 **Finish**

Generally, the standard finish shall be used unless otherwise shown on drawing or directed by the Engineer. Wherever any special treatment to the plastered surface is indicated, the work shall be done exactly as shown on the drawings, to the entire satisfaction of the Engineer regarding the texture, colour and finish.

a) **Standard Finish**

Wherever punning is indicated, the interior plaster shall be finished rough. Otherwise the interior plaster shall generally be

finished to a smooth surface. The exterior surface shall generally be finished with a wooden float.

b) **Neat Cement Finish**

Immediately after achieving a true plastered surface with the help of a wooden straight edge, the entire area shall be uniformly treated with a paste of neat cement at the rate of one (1) kg. per Sq.M. and rubbed smooth with a trowel.

c) **Coloured Plaster Finish**

This shall be done in the same way as specified in Clause 2.2.2 but using coloured cement in place of ordinary cement. When coloured plastering is specified in more than one coat, the top coat only shall be made with coloured cement.

Coloured cement shall be either ready mixed material or may be obtained by mixing pigments and cement at site, as approved by the Engineer. The pigments to be mixed with cement shall conform to Appendix-A of IS:2114 latest edition. Samples of colouring material shall be submitted to the Engineer for approval and material procured, shall conform in all respects to the approved samples, which shall remain with the Engineer. All coloured cement and/or pigments shall be stored in an approved manner in order to prevent deteriorations.

d) **Pebble-dash Finish**

Mortar of required thickness consisting of 1 part cement and 4 parts sand by volume shall be applied in the usual manner as described under plastering Clause 2.2.2. While the mortar is still plastic small pebbles or crushed stone of size generally from 10 mm to 20 mm as approved by the Engineer shall be thrown on the plastered surface. The aggregate shall be lightly tapped into the mortar with a wood float or the flat end of a trowel, in order to ensure satisfactory bond between the dashing and the mortar.

e) **Rough-Cast Finish**

A wet plastic mix of 3 parts coloured cement 6 parts sand and 4 parts aggregate by volume (gravel or crushed stone of size from 6 mm to 12 mm as approved by the Engineer) shall be thrown on to the wall by means of a plaster's trowel and left in the rough condition.

f) **Scraped Finish**

Ordinary plaster as described under Clause 2.2.2 after being levelled and allowed to stiffen for a few hours, shall be scraped

with a steel straight edge to remove the surface skin. The pattern shall be as approved by the Engineer.

g) **Textured Finish**

Mortar consisting of 1 part cement and 3 parts sand by volume shall be applied in a manner as specified under "Plastering" Clause 2.2.2. Ornamental treatments in the form of horizontal or vertical rib texture fan texture etc. shall be applied by means of suitable tools to the freshly applied plastered surface, as approved by the Engineer.

2.2.4 **Curing**

All plastered surfaces after laying, shall be watered, for a minimum period of seven days, by an approved method, and shall be protected from excessive heat and sunlight by suitable approved means. Moistening shall commence, as soon as the plaster has hardened sufficiently and not susceptible to damage. Each individual coat of plaster shall be kept damp continuously, for at least two days, and then dried thoroughly, before applying the next coat.

2.3.0 **Pointing to Masonry**

All joints of brickwork shall be raked out to a depth of 10 mm with a hooked tool made for the purpose while the mortar is still green. The brickwork shall then be brushed down with a stiff wire brush, so as to remove all loose dust from the joints and thoroughly washed with water. Mortar consisting of 1 part cement and 3 parts clean, sharp, well graded sand by volume shall be pressed carefully into the joints and finished with suitably tools to shape as shown on the drawings. Any surplus mortar shall be scraped off the wall face leaving the surface clean.

The pointed surface shall be kept wet for at least three days for curing.

2.4.0 **Plaster with Metal Lath**

The supports, hangers, brackets, cleats etc. shall be as shown on drawings and/or as approved by the Engineer. These shall have a coat of prime paint before and another coat of approved paint after erection.

The metal lath shall be expanded metal, with 12 mm x 38 mm mesh, 16 BG thick and 3 mm wide strands. Side laps shall be minimum 12 mm and end laps 25 mm minimum. The plastering shall be minimum 20 mm thick measured from the back of lath and applied in two layers.

The mortar for plastering shall consist of 1 part cement, 1/2 part lime and 4 parts sand by volume, or 1 part cement and 4 parts sand by volume mixed as specified in plastering, Clause 2.2.1. The application, finish etc. shall be as specified under relevant clause above. A 2 mm Plaster of Paris punning

shall be applied over plaster as a finishing coat to give perfectly smooth and even finish.

2.5.0 **Lime Punning**

For plastered surfaces, where an even smooth surface is specified, lime punning with 5 parts of shell lime properly slaked, strained and aged, mixed with 1 part clean, washed, sieved, fine sand by volume shall be done. The thickness of lime punning shall be not less than 2 mm and more than 3 mm. The plastered surface shall be saturated with water before application of the lime punning. The punning shall be applied by skilled workman and given a smooth and even finish free from undulations, cracks etc. and to the satisfaction of the Engineer.

2.6.0 **Plaster of Paris Punning**

Plastered surfaces, where specified shall be finished with Plaster-of-Paris punning. The material shall be from approved manufacturers and approved by the Engineer. The thickness of the punning shall be 2 mm and shall be applied by skilled workmen. The finish shall be smooth, even and free from undulation, cracks etc.

Before bulk work is taken in hand, a sample of punning shall be done on roughly 10 Sq.M. area and approval of the Engineer taken. The work shall then be taken in hand as per approved sample.

2.7.0 **Stone Facing**

Stone facing where specified shall be done as shown on design drawings and approved shop drawings. The stone shall be as specified on drawings. Samples of stone shall be submitted to the Engineer for approval and then bulk purchase made. The Contractor shall submit three copies of shop drawing for the Engineer's approval before commencing the work.

The thickness of facing stone shall be not less than 25 mm unless otherwise specified on drawings.

The stone slabs shall be cut and finished to sizes as per pattern shown on drawings. They shall be fastened to wall with suitable noncorrodable anchorage as approved by the Engineer. Where mild steel clamps, stays etc. are used for anchorage, they shall be galvanised (weight of zinc coating shall not be less than 700 gms per square meter of surface) to prevent rust stains developing on the finished surface. There shall be at least 12 mm gap between the stone and masonry, which shall be filled up and packed by a mortar of 1 part cement and 3 parts of sand by volume. After the mortar is set and cured for at least four days, the exposed surface shall be rubbed and polished as approved by the Engineer. The completed surface shall be neat, or uniform texture and acceptable to the Engineer.

Where pointing is specified on drawings it shall be done by mortar as specified on drawings.

## 3.0.0 ACCEPTANCE CRITERIA

Finish to masonry and concrete shall fully comply instructions of the Engineer with respect to lines, levels, thickness, colour, texture, pattern and any other special criteria as shown on drawings.

## 4.0.0 I.S. CODES

Important relevant code for this Section :

a) IS:1661 : Code of practice for cement and cement-lime plaster finish on walls & ceilings.

b) IS:4101 : Code of practice for external facings and veneers.

# VOLUME – II B
## CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

## SPECIFICATION NO. PE-TS-411-620-C001

## SECTION - D

## *GENERAL TECHNICAL SPECIFICATION*

## FLOOR FINISHES AND ALLIED WORKS

**Bharat Heavy Electricals Limited**
**Project Engineering Management**
**PPEI Building, Power Sector,**
**Plot No. 25, Sector 16A,**
**Noida (U.P.)-201301**

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# TECHNICAL SPECIFICATION FOR FLOOR FINISHES AND ALLIED WORKS

1.0.0 **SCOPE**

This specification covers furnishing, installation, finishing, curing, testing, protection, maintenance till handing over various types of floor finishes and allied items of work as listed below :

a) **In Situ Finishes**

i) Integral finish to concrete base

ii) Red Oxide of Iron finish

iii) Terrazzo finish

iv) Granolithic finish

v) Patent Stone

vi) Metallic Hardener like "Ironite" finish

vii) Mastic Asphalt finish

viii) Chemical Resistant finish

b) **Tiled Finishes**

i) Terrazzo tile

ii) Chequered tile

iii) Glazed tile

iv) Tesse rae (Mosaic etc.)

v) Chemical Resistant

vi) Rubber, Vinyl etc.

vii) Stone Slab

1.0.1 **Base**

The base to receive the finish is covered under other relevant specifications.

1.0.2 **Sequence**

Commencement, scheduling and sequence of the finishing works shall be planned in detail and must be specifically approved by the Engineer in view the activities of other agencies working in that area. However, the Contractor for the finishing items shall remain fully responsible for all normal precautions and vigilance to prevent any damage whatsoever till handing over.

## 2.0.0 INSTALLATION

### 2.0.1 Special Materials

Basic materials are covered under Specification "Properties Storage and Handling of Common Building Materials". Special materials required for individual finishing items are specified under respective items. In general, all such materials shall be as per relevant I.S. Codes where available. In all cases these materials shall be of the best quality available indigenously, unless specified otherwise.

The materials for finishing items must be procured from well-reputed specialised manufacturers and on the basis of approval of samples by the Engineer. The materials shall be ordered, procured and stored well in advance to avoid compulsion to use substandard items to maintain in the construction schedule.

### 2.0.2 Workmanship

Only workers specially experienced in particular items of finishing work shall be engaged, where such workers are not readily available, with the Engineer's permission, experienced supervisors recommended by the manufacturer shall be engaged. In particular cases where the Engineer so desires the Contractor shall get the finishing items installed by the manufacturer.

### 2.0.3 Preparation of the Base Surface

The surface to be treated shall be thoroughly examined by the Contractor. Any rectification necessary shall be brought to the notice of the Engineer and his approval shall be taken regarding method and extent of such rectification work.

For all types of flooring, skirting, dado and similar locations, the base to receive the finish shall be adequately roughened by chipping, raking out joints and cleaning thoroughly all dirts, grease etc. with water and hard brush and detergent if required, unless otherwise directed by the manufacturer of any special finishing materials or specifically indicated in this specification under individual item.

To prevent of water from the finishing treatment the base shall be thoroughly soaked with water and all excess water mopped up.

The surface shall be done dry where adhesives are used for fixing the finishes.

Prior to commencement of actual finishing work the approval of the Engineer shall be taken as per the acceptability of the surface.

2.1.0 **In Situ Finishes**

2.1.1 **Integral Finish To Concrete Base**

While the surface of the concrete laid as per specification for 'Cement Concrete' has been fully compacted and levelled but the concrete is still 'green' a thick slurry made with neat cement shall be applied evenly and worked in with iron floats. When the slurry starts to set it shall be pressed with iron floats to have a firm compact smooth surface without trowel mark or undulations.

This finish shall be as thin as possible by using 2.2 kg. of cement per Sq. M. of area.

The surface shall be kept in shade for 24 hours and then cured for at least 7 days continuously by flooding with water. The surface shall not be subjected to any load or abrasion till 21 days after laying.

As desired by the Engineer the surface, while still 'green' shall be indented by pressing strings. the marking shall be of even depth, in straight lines and the panels shall be of uniform and symmetrical patterns.

2.1.2 **Red Oxide of iron Finish**

It shall consist of an underbed and a topping over already laid and matured concrete base.

a) Thickness

Unless otherwise specified the total thickness of the finish shall be minimum 40 mm for horizontal and 25 mm for vertical surface of which the topping shall (not less than 10 mm) while the topping shall be of uniform thickness the underbed may vary in thickness to provide necessary slopes. The vertical surface shall project out 6 mm from the adjacent plaster or other finishes. Necessary cutting into the surface receiving the finish shall be done to accommodate the specified thickness.

All junctions of vertical with horizontal shall be rounded neatly to uniform radius of 25 mm.

b) **Mix**

i) **Underbed**

The underbed for floors and similar horizontal surfaces shall consist of a mix of 1 part cement, 2 parts coarse sand and 4 parts 10 mm down graded stone chips by volume.

For vertical and similar surfaces the mix shall consist of 1 part cement to 3 parts coarse sand by volume.

ii) **Topping**

For the topping cement, screened through a fine mesh and red oxide of iron pigment powder similarly screened shall be dry mixed thoroughly in right proportions to produce the desired colour when laid. The mix shall then be prepared with 1 part cement (mixed with pigment) and 3 parts coarse sand volume. The whole quantity required for each visible area shall be prepared in one batch to ensure uniform colour.

c) **Laying**

The underbed shall be laid in panels of mixing area 5 Sq.M. each and no side shall be more than 2.5 along. For outdoor locations the maximum area shall be 2.0 Sq.M. The forms for the panels shall have perfectly aligned edges to the full depth of the total thickness of finish. If specified aluminium or glass dividing strips shall be used.

The panels shall be laid in alternate bays or in chequered board pattern. No panel shall be cast in contact with another already laid until the contraction of the latter has taken place. The underbed shall be laid, compacted, levelled and brought to proper grade with a screed or float. The topping shall be placed after about 24 hours while the underbed is still somewhat 'green' but firm enough to receive the topping. The surface of the underbed shall be roughened for better bonding. The topping shall be rolled for horizontal areas and thrown and pressed for vertical areas to extract all superfluous cement and water to achieve a compact dense mass fully bonded with the underbed. The topping shall then be levelled up by trowelling and finished smooth with a slurry made with already prepared cement and pigment mixture. About 2.0 Kg. of the mixture shall be consumed/per Sq.M. for horizontal surface, and 1.0 Kg. for vertical surface. The surface shall be cured for seven days by keeping it moist.

d) **Polishing**

About 36 hours after laying when the surface has hardened sufficiently it shall be polished with polishing stone till a smooth shiny surface to the satisfaction of the Engineer, is achieved. The finish shall be washed and cleaned just before handing over.

2.1.3 **Terrazo Finish : In Situ**

It shall consist of an underbed and a topping laid over an already laid and matured concrete base.

a) **Thickness**

Unless otherwise specified the total thickness of the finish shall be minimum 40 mm for horizontal and 25 mm for vertical surface of which the topping shall be not less than 10 mm. While the topping shall be of uniform thickness the underbed may very in thickness to provide necessary slopes. The vertical surface shall project cut 6 mm from the adjacent plaster or other finish. Necessary cutting into the surface receiving the finish shall be done to accommodate the specified thickness.

All junctions of vertical with horizontal shall be rounded neatly to uniform radius of 25 mm.

b) **Mix**

i) **Underbed**

The underbed for floors and similar horizontal surfaces shall consist of a mix of 1 part cement, 1.1/2 parts sand and 3 parts stone chips by volume. For vertical surfaces the mix shall consist of 1 part cement to 3 parts sand by volume. The sand shall be coarse. The stone chips shall be 10 mm down well graded. Only sufficient water to be added to give a workable consistency.

ii) **Topping**

The mix for the topping shall be composed of cement, colour pigment, marble dust and marble chips. Proportions of the ingredients shall be such as to produce the terrazzo of colour texture and pattern approved by the Engineer. The cement shall be white or grey or a mixture of the two to which pigment shall be added to achieve the desired colour. To 3 parts of this mixture 1 part marble powder by volume shall be added and thoroughly mixed dry. To 1 part of this mix 1 to 1.1/2 parts of marble chips by volume shall be added and thoroughly mixed dry again.

The pigment must be stable and nonfading. It must be very finely ground. The marble powder shall be from white marble and shall be finer than IS Sieve No. : 30. The size of marble chips may be between 1 mm to 20 mm.

Sufficient quantity to cover each visible area shall be prepared in one lot to ensure uniform colour. Water to make it just workable shall be added to a quantity that can be used up immediately before it starts to set.

c) **Laying**

The underbed shall be laid in panels. The panels shall not be more than 5 sq.m in area of which no side shall be more than 2.5 M long. For exposed locations the maximum area of a panel shall be 2.0 Sq.M. The panel shall be laid in alternate bays or chequered board pattern. No panel shall be cast in contact with another already laid until the latter has contracted to the full extent.

Dividing strips made of aluminium or glass shall be used for forming the panels. The strips shall exactly match the total depth of underbed plus topping.

After laying, the underbed shall be levelled compacted and brought to proper grade with a screed or float. The topping shall be laid after about 24 hours while the underbed is still somewhat "green" but firm enough to receive the topping. A slurry of the mixture of cement and pigment already made shall be spread evenly and brushed in just before laying the topping. The topping shall be rolled for horizontal areas and thrown and pressed for vertical areas to extract all superfluous cement and water and to achieve a compact dense mass fully bonded with the underbed. The surface of the topping shall be trowelled over, pressed and brought to a smooth dense surface showing a minimum 75% area covered by marble chips in a even pattern of distribution.

d) **Curing**

The surface shall be left for curing for about 12 to 18 hours and then cured by allowing water to stand on the surface or by covering with wet sack for four days.

e) **Grinding and Polishing**

When the surface has sufficiently hardened it shall be watered and ground evenly with rapid cutting coarse grade (no.60) grit blocks, till the marble chips are exposed and the surface is smooth. Then the surface shall be thoroughly washed and cleaned. A grout with already prepared mixture of cement and pigment shall be applied to fill up all pinholes. The surface shall be cured for 7 days by keeping it moist and then ground with fine grit blocks (no.: 120). It shall again be cleaned with water, the slurry applied again to fill up any pinholes that might have appeared and allowed to be cured again for 5 days. Finally, the surface is ground a third time with very fine grit blocks (no.: 320) to get smooth surface without any pinhole. The grinding shall be done by a suitable machine. Where grinding machine can not be used hand grin- ding may be allowed when the first rubbing shall be with carborundum stone of coarse grade (no.60), second rubbing with medium grade (no.: 80) and final rubbing and polishing with fine grade (no.: 120). The surface shall be cleaned with water, dried and covered with soil free, clean sawdust if directed by the Engineer. The final

polishing shall be positioned till before handing over if desired by the Engineer. Just before handing over the surface shall be dusted with oxalic acid at the rate of 0.33 gm. per. Sq.M, water sprin- kled on to it and finished by buffing with felt or hessian bobs. The floor shall be cleaned with soft moist rag and dried. However, all excess wax polish to be wiped off and the surface to be left glossy but not slippery.

2.1.4 **Granolithic Finish**

Granolithic finish shall either be laid monolithically over base concrete or separately over hardened base concrete.

a) **Thickness**

The finish shall be average 20 mm and minimum 12 mm thick, unless specified otherwise.

b) **Mix**

The mix shall consist of 1 part cement : 1 part coarse sand : 2 parts coarse aggregate by volume. The coarse aggregate shall be very hard like granite and well graded between 6 mm and 12 mm. Minimum quantity of water to get workability shall be added.

c) **Laying of Monolithic Topping**

The concrete base shall be laid as per specification "Cement Concrete" and levelled upto the required grade. The form shall remain sufficiently protruding to take the finish.

Within about 3 hours of laying the base while it is still fully "green" the topping shall be laid evenly to proper thickness and grade. If considered necessary the surface of the base shall roughened by wire brushing. Unless manual operation is permitted by the Engineer, mechanical vibrators of suitable design shall be used to press the topping firmly and work vigorously and quickly to secure full bond with concrete base.

The laitance brought to the surface during compression shall be removed carefully without disturbing the stone chips. The surface shall then the lightly trowelled to remove all marks. When sufficiently set, hand trowelling shall be done to secure a smooth surface without disturbing the stonechips.

For large areas the laying shall be in panels of maximum 25 Sq.M area. The panels shall be laid in chequered board pattern.

d) **Laying of Topping Separately on Hardened Base**

The base concrete shall be prepared as stated in clause 2.0.3 and a slurry of neat cement applied just prior to laying the granolithic

concrete mix (1:1:2). The method of compaction etc. shall be same as for monolithic topping.

e) **Curing**

Immediately after laying, the finish shall be protected against rapid drying. As soon as the surface had hardened sufficiently, it shall be kept continuously moist for at least 10 days by means of wet gunny bags or pounding of water on the surface. The floor shall not be exposed to heavy traffic during this period.

f) **Grinding**

If grinding is specified, it shall start only after the finish has fully set. Clause 2.1.3 (c) shall be followed. However, the ultimate polish required shall be decided upon by the Engineer.

g) **Finishing**

Where specified, sodium silicate or magnesium or zinc silico fluoride treatment shall be done. The number of coats to be applied shall be as specified. The concentration and method of application of the solutions shall be as specified in IS : 5491.

2.1.5 **Patent Stone**

It shall consist of an underbed and a topping laid on an already laid and matured concrete base.

a) **Thickness**

The patent stone finish shall have thickness as stipulated under clause 2.1.2 (a) except that the topping shall be 6 mm thick.

b) **Mix**

i) **Underbed**

The mix shall be as stipulated under clause 2.1.3(b).

ii) **Topping**

The mix for the topping shall consist of 1 part cement and 1 part fine sand by volume.

c) **Laying**

The Patent Stone finish, including the underbed shall be laid in alternate bays or in chequered board pattern. No panel shall be cast in contact with another already laid till the contraction of the latter has already taken place.

The maximum area of each panel shall be 3 Sq.M of which no side shall be more than 2 M long.

A cement grout shall be applied and worked into the surface to receive the finish, the underbed then laid, compacted and levelled to proper grade with a screed or float. The topping shall be applied evenly on the underbed while it is not fully set but firm enough and rolled and pressed to get full bond.

The topping shall trowelled to a dense finish to the satisfaction of the Engineer. All trowel marks shall be mopped out with a soft cloth to give a clean smooth surface.

After the surface is sufficiently set, the finished floor shall be kept moist for 7 days for curing. If desired the finish shall be polished as directed by the Engineer.

2.1.6 **Metallic Hardener Like "Ironite" Finish**

This will consist of a topping (incorporating iron particles) to bond with concrete base while the latter is "Green".

a) **Thickness**

Unless otherwise specified the metallic hardener finish shall be of 12 mm depth.

b) **Material**

The hardening compound shall be uniformly graded iron particles free from non-ferrous metal impurities, oil, grease, sand soluble alkaline compounds or other injurious materials. When desired by the engineer, actual samples shall be tested.

c) **Mix**

Proportion of the metallic hardener shall be as specified or as indicated by the manufacturer. However, in absence of any such direction 1 part metallic hardener shall be mixed dry with 4 parts cement, by weight. To this mixture 6 mm nominal size stone chips shall be added in proportion of 1 part cement (mixed with hardener) to 2 parts of stone chips by volume and uniformly mixed. Minimum quantity of water shall be added to make it workable.

d) **Laying**

The concrete floor shall be laid as per specification "Cement Concrete" an levelled upto the required grade. The forms, if any shall remain sufficiently projecting to take the finish.

The surface shall be roughened by wire brush as soon as possible.

The finish shall be laid while the concrete underbed is still very "green" within about 3 hours of laying of the latter. The finish shall be of uniform thickness and even dense surface without trowel marks, pin holes etc. This topping layer shall be pressed firmly and worked vigorously and quickly to secure full bond with the concrete base. Just when the initial set starts the surface shall be finished \smoothened with steel trowel.

The finished floor shall be cured for 7 days by keeping it wet.

2.1.7 **Mastic Asphalt Finish**

This is a one layer treatment on concrete or brick base.

a) **Thickness**

The thickness shall be as specified in the drawing

b) **Materials**

Bitumen shall be industrial bitumen of the grades 90/15 and 75/15 conforming to IS: 702.

Mineral filler shall be dry stone dust passing through 75-micron IS Sieve.

Fine aggregate shall be crushed and graded natural lime stone or other hard-work.

Coarse aggregate shall be crushed siliceous stone or other approved aggregate 6 mm stone chips shall be used for finish upto 20 mm thick & 10 mm chips for thicker finish.

c) **Composition**

Bitumen mastic shall conform to IS: 1195 and shall be either brought to site in blocks weighing about 25Kg. or prepared at site. If brought in blocks, these shall be remelted in mechanically agitated mastic cookers and coarse aggregate, preferably preheated fed in successive portions until the complete change is thoroughly incorporated. At no stage during the remelting and mixing process, shall the temperature exceed 205°C.

d) **Laying**

The hot mastic shall be laid on dry base surface cleaned thoroughly by wire brushing and sweeping. The mastic shall be levelled and when cooled to some extent shall be finished with a wooden float with addition of small quantity of fine sand if required. No load shall be allowed till the finish has cooled to normal temperature.

The mastic shall be laid in suitable panels of about 15 Sq.M in area each formed by formers. Succeeding panels shall be laid overlapping the finish panel so as to melt its edges and form a continuous finish without joint.

2.1.8 **Chemical Resistant in Situ Finish**

Chemical resistant in situ finish shall be as epoxy resin with suitable filler material over a primer or called for in the Schedule of Items. The minimum thickness shall be 6 mm. About its performance the Engineer shall have to be fully satisfied by test results and examination of similar treatment already in existence.

The Contractor shall get it done by a specialised manufacturer, get guarantee of performance from the organisation and pass it on to the Owner in addition to his own guarantee.

2.2.0 **Tiled Finish**

These shall include finish tiles, stone slabs and similar manufactured or natural items over already laid and matured base of concrete or masonry by means of an underbed or an adhesive layer.

2.2.1 **Terrazzo Tile Finish**

The finish will consist of manufacture terrazo tile and an underbed.

a) **Thickness**

The total thickness including the underbed shall be minimum 40 mm for floors 30 mm for walls unless otherwise specified.

The skirting, dado and similar vertical surfaces shall project out 6 mm uniformly from the adjacent plaster or other wall finishes. The necessary cutting into the surface receiving the tiled finish, to accommodate the specified thickness shall be done.

b) **Tiles : Terrazzo**

The tiles shall, unless specifically permitted in special cases be machine made under quality control in a shop. The tile shall be pressed hydraulically to a minimum of 140 Kg. per Sq.cm.
Each tile shall bear on its back permanent and legible trade mark of the manufacturer. All angles of the tiles shall be right angles all arises sharp and true, colour and texture of the wearing face uniform throughout. Maximum tolerance allowance length and breadth shall be $\pm$ 1 mm and the thickness + 3 mm. Face of the tile shall be plane, free from pin holes and other blemishes.

The tiles shall be composed of a backing and topping. The topping shall be of uniform thickness not less than 10 mm.

The total thickness including the topping shall be as specified but not less than 20 mm in any case.

The backing shall be composed of 1 part ordinary grey cement and 3 parts of stone chips by weight mixed with water.

The topping shall be as specified under clause 2.1.3 (b).

The tile shall be cured at the shop for at least 14 days before delivery to the site. First grinding shall be given to the tiles at the shop before delivery. Tiles shall be packed properly to prevent damage during transit and storage. The tiles must be carefully stored to prevent staining by damp, rust, oil, and grease or other chemicals.

Tiles made in each batch shall be kept and used separately so that colour of each area of the floor may remain uniform.

The manufacturer shall supply along with the tiles the grout mix containing cement and pigment in exact proportions as used in topping of the tiles. The containers for the grout mix shall be suitably marked to relate it to the particular type and batch of tiles.

c) **Mix : Underbed**

The underbed for floor and similar horizontal surfaces shall be 1 part lime putty : 1 part surkhi : 2 parts coarse sand by weight mixed with sufficient water to form a stiff workable mass. For skirting and dado and all vertical surfaces it shall be about 12 mm thick and composed of 1 part cement and 3 parts coarse sand by weight.

d) **Laying**

The underbed mortar shall be evenly spread and brought to proper grade and consolidated to a smooth surface. The surface shall be roughened for better bond. Before the underbed had time to set and while it is still fairly moist but firm, cement shall be hand dusted over it or a cement slurry applied and the tiles shall immediately be placed upon and firmly pressed by wooden mallet on to the underbed until it achieves the desired level. The tiles shall be kept soaked for about 10 minutes just before laying. The joints between tiles shall be as close as possible and not more than 1.5 mm wide.

Special care shall be taken to check the level of the surface and the lines of the joints frequently so that they are perfect.

When tiles are required to be cut to match the dimensions these shall be sawn and edges rubbed smooth. The location of cut tiles shall be planned in advance and approval of the Engineer taken.

At the junction of horizontal surface with vertical surface the tiles on the former shall enter at least 12 mm under the latter.

After fixing, the floor shall be kept moist and allowed to mature undisturbed for 7 days. Heavy traffic shall not be allowed.

If desired dividing strips as specified under Clause 2.1.3 (c) may be used for dividing the work into suitable panels.

e) **Grinding and Polishing**

Procedure shall be same as Clause 2.1.3 (c) 2. Grinding shall not commence earlier than 14 days after laying of tiles.

2.2.2 **Chequered Tile Finish**

The finish shall consist of manufactured grey or coloured cement tiles or terrazzo tiles with chequered face and an underbed laid over concrete or brick surface.

a) **Thickness**

Thickness shall be same as in clause 2.2.1 (a).

b) **Tiles : Chequered**

The tiles shall have chequers not less than 2.5 cm. c/c and not more than 5 cm c/c, Depth of grooves shall be not less than 5 mm. The grooves shall be uniform and straight.

The tiles shall conform to clause 2.2.1 (b) except that these may have the topping in terrazzo or plain grey cement or colour pigment added to cement as specified.

c) **Underbed**

As per clause 2.2.1 (c).

d) **Laying**

As per clause 2.2.1 (d).

e) **Grinding and Polishing**

As per clause 2.2.1 (e) except that the tiles shall be ground and polished by hand after laying taking special care in polishing the grooves properly and uniformly.

2.2.3 **Glazed Tiles Finish**

This finish shall be composed of glazed earthenware tiles with an underbed laid over a concrete or masonry base.

a) **Thickness**

The total thickness shall be between 20 mm and 25 mm including the underbed. The tile finish on vertical surface shall project out 6 mm uniformly from the adjacent plaster or other wall finishes. The necessary cutting into the surface receiving the finish, to accommodate the specified thickness shall be done.

b) Tiles : Glazed

The tiles shall be of earthenware, covered with glaze white or coloured, plain or with designs, of 150 mm x 150 mm nominal sizes and 10 mm thick unless otherwise specified. The tolerance shall be $\pm$ 1.5 mm for length and breadth and $\pm$ 0.5 mm for thickness specials like internal and external angles, beads, covers, cornices, corner pieces etc. shall match. The top surface of the tiles shall be glazed with a gloss or matt unfading stable finish as desired by the Engineer. The tiles shall be flat and true to shape. The colour shall be uniform and fractured section shall be fine grained in extures, dense and homogeneous. The tiles shall be strong and free from flaws like cracks, craze, specks, crawlings, etc. and other imperfections. The edge and the underside of the tiles shall be completely free from glaze and the underside shall have ribs or indentations for better anchorage with the fixing mortar.

The coloured tiles, when supplied, shall preferably come from one batch to avoid difference in colour.

c) **Mix : Underbed**

The mix for the underbed shall consist of 1 part cement and 3 parts coarse sand by weight mixed with sufficient water or any other mix if specified.

d) **Laying**

Same as clause 2.2.1 (d).

e) **Finishing**

The joints shall be cleaned and flush pointed with white cement and cured for 7 days by keeping it wet. The surface shall be cleaned with soap or suitable detergent, washed fully and wiped with soft cloth to prevent scratching before handing over.

2.2.4 **Tesserae Finish** (Mosaic etc.)

This finish consists of manufactured vitreous, glass, ceramic or similar hard small pieces set in an underbed over a concrete or masonry surface, already laid.

a) **Thickness**

The total thickness including the underbed shall be between 16 mm and 25 mm.

b) **Tesserae Finish**

These shall usually be 6 mm thick small piece of ceramic vitreous china, tinted glass or similar hard wearing, strong and durable material in desired shapes and sizes and patterns.

The supply shall come in the desired pattern in full or sections conveniently for handling, stuck to pieces of strong thick paper on the surface to be exposed. The gum used for this purpose must be water soluble and non-staining. The sections shall be properly marked to avoid mistakes and master drawing shall be available at the site for guidance.

c) **Mix : Underbed**

Same as clause 2.2.3 (c)

d) **Laying**

The specification for laying if given by the manufacturer of the item shall be followed provided it is approved by the Engineer. Otherwise clause 2.2.3 (d) shall generally be followed. However, instead of grey cement the slurry shall be made with white cement to fix the panels. The paper mounted patterns in sections shall be carefully placed and pressed in position true to lines and levels. Earliest possible the paper shall be peeled off and surface examined and cleaned, joints flush pointed with white cement and cured for 7 days by keeping it wet.

2.2.5 **Chemical Resistant Tiled Finish**

This shall include all varieties of special tiles used for specific chemical resistance function and an underbed over already laid concrete or masonry.

a) Tiles

The chemical resistant tiles as detailed in the Schedule of items shall be of the best indigenous manufacture unless otherwise specified and shall be resistant to the chemical described in the Schedule of Items. The tiles shall have straight edges, uniform thickness, plain surface, uniform non-fading colour and textures.

Glazed tiles if permitted to act as chemical resistant finish shall be considered under clause 2.2.3.

Usually the chemical resistant tiles shall not absorb water more than 2% by weight. The tiles shall have at least compression strength of 700 Kg/cm2. The surface shall be abrasion resistant and durable.

b) **Laying**

The mortar used for setting or for underbed the tiles shall be durable and strong. The grout which shall be to the full depth of tile shall have equal chemical resistant properties. Joints shall be pointed if so desired. The setting and fixing shall be according to the manufacturer's specification approved by the Engineer.

2.2.6 **Rubber, Vinyl or Vinyl Asbestos Tiles Finish**

This shall include various types of tiles manufactured from rubber, vinyl, etc. set with a adhesive on concrete or masonry base. An underbed may be required to secure desirable surface and grade.

a) **Thickness**

The thickness of the tiles shall be mentioned in the Schedule or in drawing.

b) **Tiles**

Unless otherwise desired the tiles shall be squares of approved dimensions.The tolerance in dimensions shall be $\pm$ 1.5mm.

The face of the tiles shall be free from porosity, blisters, cracks, embedded foreign matters or either physical defects which affect appearance or serviceability. All edges shall be cut true and square. The colour shall be nonfading and uniform in appearance, insoluble in water and resistant to alkalies, cleaning agents and usual floor polishes.

Each tile shall be marked on the back legibly and indelibly with manufacturer’s trade mark, the thickness, sizes, batch number and date of manufacturer.

Tiles shall be delivered securely packed and stored in clean, dry well ventilated place at a temperature near about to that the tiles shall be called upon to stand ultimately.

Adhesive to be used for sticking the tiles shall be approved by the tile manufacturer. The adhesive shall have a short drying time and long life in addition to toughness.

c) **Mix : Underbed**

The underbed where required to make up the specified thickness or to give the required grade or to get the right type of surface shall be composed of 1 part like putty : 1 part cement : 4 parts coarse sand mixed with just sufficient water to make it workable.

d) **Laying**

The tiles shall be kept in the room to be tiled for at least 24 hours to bring them to the same temperature as the room. For air conditioned space, the air-conditioning shall be completed before tiling is taken up.

The surface to receive this finish shall be firm even textured but not too smooth, without undulations and other deficiencies. If an underbed is laid the same shall be cured for at least 7 days by keeping it moist and then fully dried.

The surface shall be thoroughly cleaned. All loose dust particles shall be removed. Oil and grease if any shall be completely cleaned by use of detergent.

The adhesive shall be applied to fully dry surface in desired thickness uniformly. The adhesive shall also be applied to the backs and edges of the tiles and allowed to surface dry. The tiles shall be placed neatly on the surface exactly to the approved pattern and set with a suitable tool. If the edges tend to curl, weights are to be used to keep the edges down. Special care shall be taken to avoid formation of air pockets under the tiles. The joints shall be very fine. Any adhesive squeezed out through the joints shall be removed immediately.

e) **Finishing**

If any adhesive mark is there on the surface a soft cloth soaked in solvent shall be used to wipe it off. The surface shall be cleaned with soft soap, dried and polished with an approved type of polish just before handing over.

2.2.7 **Stone Slab Finish : Marble, Stone and Similar Fine Grained Stone**

a) **Thickness**

The underbed shall be minimum 12 mm and average 20 mm thick. The slabs may be 25 mm, 30 mm or 40 mm thick as specified.

b) **Stone Slab**

The stone slabs shall be made from selected stock which are hard, sound, homogeneous and dense in texture and free from flaws. Angles and edges shall be true, square, free from chipping and surface shall be plane. The slabs shall preferably be machine cut to the required dimensions.

Tolerance of ± 5 mm in dimensions and ± 2 mm in thickness will be allowed. Unless specified the slabs shall be minimum 300 mm x 300 mm.

The stone slabs shall come from specific regions and in specified quality with top surface fine chisel dressed. All sides shall also be fine chisel dressed to the full depth to allow finest possible joints.

The slabs shall be delivered to the site well protected against damages and stored in dry place under cover.

c) **Mix : Underbed**

Same as clause 2.2.1 (c).

d) **Laying**

The sides and top surface of the slabs shall be machine rubbed or table rubbed with coarse sand stone and washed clean before laying.

The underbed mortar shall be evenly spread and brought to proper level on the area under each slab. The slab shall be laid over the underbed, pressed and tapped down with wooden mallet to the proper level. The slab shall then be lifted and the underbed corrected as necessary and allowed to stiffen a little. Next, a thick cement slurry shall be spread over the surface. The edges of the slab shall be buttered with slurry of cement, grey/white/mixed with pigment matching the colour of the stone slabs. The slab shall be gently laid and tapped with wooden mallet to bed properly to a very fine joint and to the required level. All surplus cement slurry shall be removed and the surface mopped clean with wet soft cloth. The laid finish shall be cured for 7 days by keeping it wet.

e) **Polishing, Finishing**

Fine chiselling shall be done to remove the slight undulations that usually exist at the joints. The polishing and finishing shall be done as specified under clause 2.2.1 (e). However, the joints shall be so fine in the case of stone slabs that grouting shall not be called for.

2.2.8 **Stone Slab Finish : Sand Stone and Similar Coarse Grained Stone Finish**

Generally clause 2.2.7 shall be followed except that the workmanship and finish shall not be fine as which are explained hereunder.

The slabs shall be rough chiseled or fine chiseled as specified. Tolerance may be allowed upto $\pm$ 6 mm for rough finish, but no sharp unevenness and shall be allowed. For fine chiseling the unevenness shall be limited to $\pm$ 2 mm. The sides shall be chisel dressed at least to half slab depth so that the maximum deviation from straight line shall be within 25 mm. Beyond this depth the edge may be slightly splayed.

The joint thickness shall be kept limited to 5 mm in case of rough finish and 3 mm in case of fine finish unless wider joints are specified. The joints shall be grouted with white or coloured cement.

## 3.0.0 ACCEPTANCE CRITERIA

The finish shall be checked specially for :

a) Level, Slope, Plumb as the case may be

b) Pattern and Symmetry

c) Alignment of joints, dividing strip etc.

d) Colour, texture

e) Surface finish

f) Thickness of joints

g) Details at edges, junctions etc.

h) Performance

i) Precautions specified for durability

## 4.0.0 I.S. CODES

Important relevant codes for this section :

| | | |
|---|---|---|
| IS : 777 | : | Glazed earthenware tiles |
| IS : 1196 | : | Code of practice for laying bitumen mastic flooring |
| IS : 1197 | : | Code of practice for laying of rubber floors |
| IS : 1237 | : | Cement concrete flooring tiles |
| IS : 1443 | : | Code of practice for laying and finishing of cement concrete flooring tiles |
| IS : 2114 | : | Code of practice for laying in situ terrazzo floor |

| | | |
|---|---|---|
| IS : 3461 | : | PVC asbestos floor tiles |
| IS : 4860 | : | Specification for acid resistant bricks |
| IS : 5518 | : | Code of practice for laying of flexible PVC Sheet and tile flooring. |
| IS : 5491 | : | Code of practice for laying in situ granolithic floor topping. |

# VOLUME – II B
## CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

## SPECIFICATION NO. PE-TS-411-620-C001

## SECTION - D

## *GENERAL TECHNICAL SPECIFICATION*

## MISCELLANEOUS METAL

**Bharat Heavy Electricals Limited**
**Project Engineering Management**
**PPEI Building, Power Sector,**
**Plot No. 25, Sector 16A,**
**Noida (U.P.)-201301**

## TABLE OF CONTENT

# TECHNICAL SPECIFICATION FOR MISCELLANEOUS METAL

## 1.0.0 SCOPE

This specification shall generally be read in conjunction with item nos. 6.01 & 6.03.

This shall include supply, fabrication and erection of miscellaneous metal items of light nature in gates, grills, balcony and stair handrails particulars, structural mullions and transoms, ladders hangers masonry anchors, shelf angles, anchor bolts, fasteners, etc. as shown on drawing or as instructed by the Engineer. The above items shall be of fabricated or cast M.S/Aluminium/Brass, cast iron, M.S. and galvanised M.S. Sheets, aluminium sheets, expanded metal, wire mesh etc. as shown on drawings and/or described.

## 2.0.0 INSTALLATION

### 2.1.0 Fabrication/Casting

#### 2.1.1 General

All work shall be done according to approved shop drawings. All workmanship shall be equal to the best practice in modern structural or foundry shop.

#### 2.1.2 Shop Connections

a) All shop connections shall be riveted or welded except when noted otherwise on drawings.

b) Welding of steel shall be done in accordance with the IS : 816. Use of metal arc welding for general construction in Mild Steel.

c) Welding of aluminium shall be done in accordance with IS: 2812, Arc welding of Aluminium and Alloys, Special care shall be taken to grind smooth all welded surface that shall remain exposed to view. Welds shall be electrically continuous if so required by the Engineer.

#### 2.1.3 Shop Coat

Before leaving the shop, all metal work shall be thoroughly cleaned by effective means of all loose mill/ scale, rust and foreign matter. Except where encased in concrete, all steelwork shall be given one coat of approved metal protective paint, applied by brush thoroughly and evenly, well worked into joints and other open spaces. All paint shall be applied to dry surfaces. Steel work shall be galvanised or galvanized and painted with a coat of zinc chromate primer. Aluminium surfaces which shall come in contact with masonry shall be given one coat of zinc chromate primer.

2.2.0 **Erection**

2.2.1 **Bracing**

The Contractor shall provide all necessary temporary guys and braces to ensure alignment and stability of the members and to take care of all loads to which the structure may be subjected including erection of equipment and operation of the same.

2.2.2 **Temporary Bolting-Up**

As erection proceeds the Contractor shall plumb up and level all members and shall securely bolt up to take care of all dead load, wind load and erection stresses. Wherever piles of materials, erection equipment or other loads are carried during erection, proper provision shall be made to take care of the stresses resulting from the same.

2.2.3 **Turned Bolt**

For field connections where bolting is specified, holes for the turned bolts may be reamed in the field, if required. All drilling or reaming for turned bolts shall be done after the parts to be connected are assembled.

2.2.4 **Welding**

Where specified on drawings, welding shall be done in accordance with IS : 816 for steel and IS: 2812 for Aluminium and Alloys.

2.2.5 **Cutting and Fitting**

No cutting of sections, flanges, webs of angles shall be done without the approval of the Engineer. Where indicated on the drawings, holes, cuttings, etc. shall be provided as required for installation, to the work by the other Contractors. No additional holes or cuttings, than those shown on drawings, shall be made without the approval of the Engineer.

2.2.6 **Drifting**

Correction of minor misfits and a reasonable amount of reaming and cutting of excess stock from rivets may be permitted. For this, light drifting may be allowed to draw holes together. Twist drills shall be used to enlarge as necessary to make connections. Reaming that weakens the members or make it impossible to fill the holes properly or to adjust accurately after reaming shall not be allowed.

Any error in shop work which prevents the proper assembling and fitting of parts by moderate use of drift pins or a moderate amount or reaming and slight chipping and cutting shall immediately be called to the attention of the Engineer and approval of the method of correction obtained. The use of cutting torches to enlarge or alter rivet holes shall not be permitted.

2.2.7 **Grouting**

All bearing plates, loose lintels and beams, etc. shall be set to proper grade and level by the Contractor and the Engineer's approval obtained before proceeding with the grouting. Grouting shall be done in 1:1.5:3 or 1:1- 1/2:3 concrete with 6 mm down stone chips.

2.2.8 **Anchor Bolting**

When shown on drawings, the miscellaneous metal items shall be fixed to concrete by case hardened and drawn carbonizing steel expander nut and bolt. The Contractor shall submit the manufacturer's literature showing the average pull out and average shear values for bolts of various sizes. The bolts shall be fixed strictly as per the manufacturer's instructions.

2.2.9 **Pipe Joints**

M.S. Pipes shall be joined by threaded sockets or by welding. Cast iron pipes shall be socket and spigot jointed and caulked with hemp and molten lead.

2.2.10 **Spot Painting**

All field rivets and bolts and also any serious abrasion to shop paint shall be spot painted with the same materials as used for the shop paint.

2.2.11 **Making Good**

All cutting to concrete or masonry shall be made good to the satisfaction of the Engineer.

3.0.0 **ACCEPTANCE CRITERIA**

a) All items shall be of correct shape, size, weight etc. shown on drawings.

b) For installed items, the tolerances shall be follows :

i) Permissible deviation from straightness - 1 in 1000.

ii) Seats, stiffener connections etc. shall be as per approved drawings and shall not interfere with architectural clearances.

c) All castings shall be free from blow holes, cracks and other blemishes.

4.0.0 **I.S. CODES**

IS : 226 - Structural Steel (Standard Quality)

IS:800 - Code of practice for use of structural steel in general building construction.

IS : 816 - Use of metal arc welding for general construction in mild steel.

IS : 2812 - Arc welding of Aluminium and Alloys

IS : 3150 - Hexagonal Wire Netting

IS : 4948 - Welded steel wire fabric for general use.

# VOLUME – II B
## CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

## SPECIFICATION NO. PE-TS-411-620-C001

## SECTION - D

## *GENERAL TECHNICAL SPECIFICATION*

## PAINTING, WHITE WASHING AND POLISHING ETC.

**Bharat Heavy Electricals Limited**
**Project Engineering Management**
**PPEI Building, Power Sector,**
**Plot No. 25, Sector 16A,**
**Noida (U.P.)-201301**

## TABLE OF CONTENT

# TECHNICAL SPECIFICATION FOR PAINTING, WHITE WASHING AND POLISHING ETC.

## 1.0.0 SCOPE

This specification covers painting, white washing, varnishing, polishing etc. of both interior and exterior surfaces of wood work, masonry, concrete plastering, plaster or paris,Punning false ceiling, structural and other miscellaneous steel items, rain water down comer, floor and roof drains, soil, waste and service water pipes, and other ferrous and non-ferrous metal items as shown on drawings, or as directed by the Engineer.

Copper, bronze, chromium plate, nickel, stainless steel, aluminium and monel metal shall generally not be painted or finished except if otherwise specified.

The painting Contractor shall inspect the work of others prior to the application of paint. If surface to be finished cannot be put in suitable condition for painting by customary preparatory methods, the painting contractor shall notify the Engineer in writing or assume responsibility for and rectify unsatisfactory finishing that results.

Before commencing painting, the painting Contractor shall obtain the approval of the Engineer in writing regarding the schedule of work to minimize damage, disfiguration or staining by other trades. He shall also undertake normal precautions to prevent damage, disfiguration or staining to work of other trades or other installations.

## 2.0.0 INSTALLATION

### 2.0.1 Materials

Materials shall be highest grade products or well-known approved manufacture and shall be delivered to the site in original sealed containers, bearing brand name, manufacturer's name and colour shade, with labels intact and seals unbroken. All materials shall be subject to inspection, analysis and approved by the Engineer. It is desired that materials of one manufacturer only shall be used as far as possible & paint or one shade is obtained the same manufacturing batch. All paint shall be subject to analysis from random samples taken at site from painters bucket, if so desired by the Engineer.

All prime coats shall be compatible to the material of the surface to be finished as well as to the finishing coats to be applied.

All unspecified materials such as shellac, turpentine or linseed oil shall be of the highest quality available and shall conform to the latest IS standards. All

such materials shall be made by reputable recognised manufacturers and shall be approved by the Engineer.

All colours shall be as per painting schedule and tinting and matching shall be done to the satisfaction of the Engineer. In such cases, where samples are required, they shall be executed in advance with the specified materials for the approval of the Engineer.

a) **White Washing**

Shall be done from pure shell lime or fat lime, or a mixture of both as instructed by the Engineer; and shall conform to IS:712 latest edition. Samples of lime shall be submitted to the Engineer for approval, and lime as per approved sample shall be brought to site in unslaked condition. After slaking, it shall be allowed to remain in a tank of water for two days and then stirred up with a pole, until it attains the consistency of thin cream. 100 grams of gum to 6 litres of white wash water and a little quantity of indigo or synthetic ultramarine blue shall be added to the lime.

b) **Dry distemper**

Shall be made from suitable pigments, extenders, lime proof tinters, water soluble binders etc. and shall conform to IS:427.

c) **Oil Bound Washable Distemper**

Shall be of oil emulsion type, containing suitable preservatives and shall conform to IS:428.

d) **Waterproof Cement Paint**

Shall be made from best quality white cement and lime resistant colours with accelerators, waterproofing agents and fungicides. The paint shall conform to IS:5410.

e) **Acrylic Emulsion Paint**

Shall be water-based acrylic copolymer emulsion with retile titanium dioxide and other selected pigments and fungicide. It shall exhibit excellent adhesion to plaster and cement surface and shall resist deterioration by alkali salts. The paint film shall allow the moisture in wall to escape without peeling or blistering. The paint, after it is dried, shall be able to withstand washing with mild and water without any deterioration in colour, or without showing flaking, blistering or peeling.

f) **Synthetic Enamel Paint**

Shall be made from synthetic resins and drying oil with rutile titanium dioxide and other selected pigments to give a smooth, hard, durable and glossy finish to all exterior and interior surfaces. White and pastel shades shall resist yellowing and darkening with aging. The paint shall conform to IS:2932 and IS:2933.

g) **Aluminium Paint**

Shall be in two pack containers and shall resist weathering. The paint shall conform to IS:2339.

h) Shall be best quality alkyd varnish suitable for brushing over the tint of paint or light natural wood and shall not darken or yellow with age.

i) **French Polish**

Shall be made from best quality shellac, denatured spirit and other suitable alcohol soluble ingredients and made by a well known approved manufacturer. The material shall conform to IS:348.

French polish shall not be used on bare wood. It shall only be used as finishing coat on wood after the wood is pretreated with a liquid wood filler conforming to IS:345 is applied and rubbed out.

2.0.2 **Storage**

The Contractor shall arrange for safe and proper storage of all materials and tools. The storage space if allotted within the building shall be adequately protected from damage, disfigurement & stains. Paint shall be kept covered at all times and mixing shall be done in suitable containers. All necessary precautions shall be taken by the Contractor to prevent fire.

2.1.0 **Preparation of surface**

Before starting the work the Contractor shall obtain the approval of the Engineer regarding the soundness & readiness of the surface to be painted on.

2.1.1 **Wood**

All surfaces shall be free from dirt and loose or peeling paints. The surface shall be rubbed down smooth. All nails & screws shall be sunk below the surface and filled with putty after applying an under coat. Small knots that do not justify cutting and sap streaks shall be covered with minimum 2 coats of pure shellac coating applied thinly & extended 25 mm beyond the area. All large, loose or resinous knots shall be removed and filled with sound wood. All work shall be done as per IS:2338.

2.1.2 **Masonry, Concrete and Plastered Surface**

Surface shall be free from all oil, grease, efflorescence, mildew, loose paint or other foreign and loose materials. Masonry cracks shall be cleaned out and patch filled with mortar similar to the original surface and uniformly textured. Where this type of re- surfacing may lead to the finishing paint being different in shade from the original surfaces, the resurfaces area shall be treated with minimum one coat of cement primer, which should be continued to the surrounding area for a distance of minimum 100 mm.

Surface with mildew or efflorescence shall be treated as below :

a) **Mildew**

All mildewed surfaces shall be treated with an approved fungicide such as ammonia cal wash consisting of 7g of copper carbonate dissolved in 80 ml. liquor ammonia and diluted to 1 litre with water, or 2.5 percent magnesium silicofluoride solution and allowed to dry thoroughly before paint is applied.

2.1.3 **Metal**

All metal surfaces shall be absolutely clean, dry and free from wax, grease or dried soap films. In addition, all steel and iron surfaces shall be free from rust, surfaces shall be cleaned by mechanical power tools to remove mill scales unless otherwise approved by the Engineer for exposed chemical resistant paints, surfaces shall be blast cleaned to near white metal. All galvanised iron surfaces shall be pretreated with a compatible primer according to the manufacturer's direction. Any abrasion in shop coat shall be touched up with the same quality of paint as the original coat.

2.2.0 **Application**

2.2.1 **General**

The method of application shall be as recommended by the manufacturer. In case of selection of special shades and colour (not available in standard shades) the Contractor shall mix different shades and prepare test panels of minimum size 1 meter square as per instruction of the Engineer and obtain his approval prior of application of finishing paints.

Proper tools and implements shall be used. Scaffoldings if used shall be independent of the surface to be painted to avoid shade differences of the freshly repaired anchor holes.

Painting shall be done by skilled labours in a workmanlike manner. All materials shall be evenly applied so as to be free of sags, runs, crawls or other defects. All coats shall be of proper consistency. In case of application by brush, no brush marks shall be visible. The brushes shall be clean and in good condition before application of paint.

All priming undercoats for painting shall be applied by brush only, and rollers spray equipments etc. shall not be used.

No work shall be done under conditions that are unsuitable for production of good results. No painting shall be done when plastering is in progress or is drying. Application of paint, which seals the surfaces to moisture, shall only be done after the moisture on and below the surface has dried out.

All coats shall be thoroughly dry before succeeding coat is applied. Coats of painting as specified are intended to cover surfaces perfectly. In case the surface is not covered properly by applying the specified number of coats, further coats shall be applied by the Contractor when so desired by the Engineer.

All primers and undercoats shall be tinted to approximate the colour of the finishing coats. Finished coats shall be of exact colour and shade as per approved samples and all finish shall be uniform in colour and texture. All parts of mouldings and ornaments shall be left clean and true to finish.

Painting on ferrous metal surface shall be done as per IS:1477 (Part 1 & 2). The total dry thickness of the film should not be less than 120 micron.

### 2.2.2 White Washing

The surface where white washing is to be applied shall be cleared of all loose materials and dirt. All holes and irregularities of the surface shall be filled up with lime putty and shall be allowed to dry up before application of the lime solution.

One coat of whitewash shall consist of one stroke from top downwards, another from bottom upwards over the first stroke and another from left to right before the previous one dries up. Second coat shall be applied and in case the Engineer feels that one or more coats are required. No brush marks shall show on the finished surface.

### 2.2.3 Dry Distemper

New plastered surface shall be allowed to dry for at least two months. New lime or lime cement plastered surface shall be washed with a solution of 1 part Vinegar to 12 parts water or 1:50 sulphuric acid solution and for 24 hours after which the wall shall be thoroughly washed with clean water. For cement plastered surface, the surface shall be washed with a solution of 100 gms. of zinc sulphate to 1 litre of water and then allowed to dry.

Dry distempering shall be done as per manufacturer's instruction. In applying the distempers the brush should first be applied horizontally and immediately crossed off perpendicularly. Brushing shall not be continued too long as otherwise brush marks may result.

2.2.4 **Oil bound washable distemper**

The distemper shall be applied after surface is primed with an alkali resistant primer, and followed by minimum two coats of oil bound washable distemper all as per manufacturer's instruction.

2.2.5 **Waterproof Cement Paint**

Surface to be coated with cement paint shall be washed and brushed down. As soon as the moisture has disappeared, the surface shall be given one coat of paint. Care shall be taken so that the paint does not dry out too rapidly. After 4 to 6 hours, the water shall be sprinkled over the surface to assist curing and prevent cracking. After the first coat has dried (24 to 48 hours) the second coat shall be applied in a similar manner. The finished surface shall be kept moist by occasional sprinkling with water for seven days after painting.

2.2.6 **Acrylic Emulsion Paint**

Lime gauged cement plastered surfaces shall not be painted for at least one month after plastering. A sample patch shall be painted to check alkali reaction if so desired by the Engineer. Painting shall be strictly as per manufacturer's specification.

2.2.7 **Synthetic Enamel Paint**

Shall be applied on properly prime red surface. Subsequential coat shall not be applied till the previous coat is dry. The previous shall be lightly sand papered for better adhesion of subsequent coats.

2.2.8 **Aluminium Pain**t

The paint, supplied in two pack containers shall be mixed and applied strictly as per manufacturer's direction. When more than one coat of paint is required or indicated, the next coat shall only be applied after the previous coat become hard dry.

2.2.9 **Clear Synthetic Varnish**

The Varnish shall be applied on wood surface after (a) filling, (b) staining & (c) sealing operations are carried out. The application of a combination of filler and stain shall not be permitted.

For the finishing coats of varnish, the surface shall be allowed to dry and be rubbed down lightly, wiped off and allowed to dry. Careful attention to cleanliness is required for varnishing. All dust and dirt shall be removed from the surface as well as from the neighbourhood. Damp atmosphere and draughts shall be avoided, and exposure to extreme heat or cold & dampness shall not be allowed.

The varnish shall be applied liberally with a brush and spread evenly over a portion of the surface with light strokes to avoid frothing. It shall be allowed to flow on while the next section is being laid on excess varnish shall then be scrapped off the brush and the first section be crossed, recrossed and then laid off lightly. The varnish once it has began to set, shall not be retouched. In case of any mistake in application, the varnish shall be removed and the work started afresh.

The varnish shall be minimum of two coats, with the first coat being a flatting varnish. This shall be allowed to dry hard and be flatted down, before applying the next coat. Sufficient time must be allowed between coats to get a hard dry surface before next coat is applied. All work shall be as per relevant IS Code.

2.2.10 **French Polish**

All unevenness of the surface shall be rubbed down to smoothness with sand paper and the surface shall well dusted. The pores in the wood shall be filled up with a paste of whitening in water or methylated spirit with a suitable pigment like burnt siemma or umber.

After application of the filler paste, the french polish shall be applied with a pad of woolen cloth covered by a fine cloth. The pad shall be moistened with polish and rubbed hard on the surface in a series of overlapping circles so that the polish is sparingly but uniformly applied over the entire area to give an even surface. A trace of linseed oil may be used on the pad for case of application. The surface shall be allowed to dry before further coats are applied in the same manner. To finish off, the pad shall be covered with a fresh piece of clean fine cloth, slightly damped with methylated spirit and rubbed lightly and quickly with circular motions to leave the finished surface with a uniform texture and high gloss.

2.2.11 **Chemical Resistant Paint**

For chemical resistant paints, epoxy, chlorinated rubber or vinyl butyl paint system shall be used manufacturer's recommendation regarding the paint system exposed to moderately severe corrosive condition and subject to acid/alkali spillage and fumes, shall be followed.

2.2.12 **Epoxy coating/painting**

On the clean surface of concrete after properly drying of the following system is to be adopted as per manufacturers specification :

One coat of primer of following proportion to be applied over clean and dried concrete surface by brush application.

**ARALDITE GY 250 - 100 Parts by weight**

**HARDENER HY 840 - 50 Parts by weight**

Over the primer, the uneven surface of concrete should be filled with leveling putty as mentioned above. The cost of putty is included in the item rate without fixing prior limit to consumption of putty. Two top coats of the protective treatment to be applied over the prepared smooth surface in the following proportion.

**ARALDITE GY 250 - 100 Parts by weight**

**HARDENER HY 830 - 45 Parts by weight**

**HARDENER BY 850 - 15 Parts by weight**

**SILICA FLOUR - 20 Parts by weight**

**FLOW CONTROL AGENT - 2 Parts by weight**

Pigment may be added if desired by Engineer. The first top coat is applied over the primer and is left to reach a tack free state. At this stage, the final top coat is applied.

2.3.0 **Protection**

Furniture and other movable objects, equipments, fittings and accessories shall be moved, protected and replaced upon completion of work. All stationary equipments shall be well covered so that no paint can fall on them. Work finished by other agencies shall be well protected. All protections shall be done as per instructions of the Engineer.

2.4.0 **Cleaning up**

In addition to provisions in general conditions the Contractor shall, upon completion of painting etc. remove all marks and make good surfaces, where paint has been spilled, splashed or splattered, including all equipments, fixtures, glass, furniture, fittings etc. to the satisfaction of the Engineer.

3.0.0 **ACCEPTANCE CRITERIA**

a) All painted surfaces shall be uniform and pleasing in appearance.

b) All varnished surfaces shall be of uniform texture and high glossy finish.

c) The colour, texture etc. shall match exactly with those of approved samples.

d) All stains, splashes and splatters of paints and varnishes shall be removed from surrounding surfaces.

4.0.0 **I.S. CODE**

Important relevant IS Codes for this Sections are listed below :

| | | |
|---|---|---|
| IS:348 | : | Specification for French Polish |
| IS:427 | : | Specification for Distemper, dry colour as required. |
| IS:428 | : | Specification for Distemper oil emulsion, colour as required. |
| IS:1477 | : | Code of Practice for painting of ferrous (I&II)metal in buildings. |
| IS:2338 | : | Code of Practice for finishing of wood (I&II)and wood based materials. |
| IS:2339 purposes | : | Specification for Aluminium Paints for general in dual containers. |
| IS:2395 | : | Code of Practice for painting concrete, masonry and plaster surface. |
| IS:2932 | : | Specification for enamel, synthetic, exterior, type-I. |
| IS:5410 | : | Specification for cement paint, colour as required. |

# SECTION - D
# SUB-SECTION – A6

# STACK ELEVATOR

## 1. DESIGN AND CONSTRUCTION

### 1.1 Stack Elevator - General

1.1.1 The stack elevator including mechanical and electrical components shall be installed outside/inside Single flue/ multi flue chimney. Since chimney is a free standing structure, deflection of chimney top is expected during the normal operation, so the design of the elevator shall be in such a way that the elevator operation will be safe even with the expected maximum deflection of the chimney structure. The stack elevator shall lift a pay load as indicated against rated load as mentioned in Data sheet-A or its nearest as per manufacturer's present standard in addition to the weight of the car and its accessories and shall travel at a rated speed as indicated in the data sheet-A. Travel of the elevator car, number of landings and levels shall be as per Data sheet-A attached to this section.

1.1.2 Stack elevator mechanical and electrical operating devices and trailing cable shall be designed for operation indoors/out door with dusty and high humidity conditions and shall operate equally well in any ambient temperature encountered in the site conditions. Additionally, all mechanical and electrical components of the elevator shall be designed to withstand without damage a temperature of 100$^{o}$C when the elevator is not operating.

1.1.3 Cage earthing shall be done through trailing cable.

1.1.4 Stack elevator shall be attached to the chimney shell using expansion type anchor bolts drilled in to chimney shell. Elevator shall be capable of operating from the ground floor to the top platform with intermediate stops at all platforms. Landing for elevator parking shall be one (1) metre above the stack ground floor. Suitable concrete/brick steps leading to the landing for entry to cabin shall also be provided,

1.1.5 The stack elevator shall be designed in line with recommendations contained in the latest editions of the applicable codes and standards.

### 1.2 Equipment Specification

1.2.1 Enclosures

i. A three-sided enclosure with one access door shall be provided at graded level. At each platform landing above graded level, a one sided enclosure with access door shall be provided. Enclosures shall be fabricated from tubular steel and expanded metal or wire mesh, 2.1 m high and one coat of epoxy primer coated. Enclosure access doors shall be electrically and mechanically interlocked so that they remain closed and locked except when the Cab is at the landing. Doors shall be bi-parting and swinging type.

ii. Base of three-sided enclosure shall be securely anchored to the grade level floor slab using expansion type anchors.

1.2.2 Mast

i. Mast shall be provided in sections approximately 1.52 m in lengths considering of tubular sections and/or structural shapes welded together to form a frame work to which the rack is bolted. Mast shall be securely anchored to the concrete chimney walls.

1.2.3 Cab

i. Cab frame shall be fabricated from tubular steel and enclosed with expanded metal or wire mesh.

ii. Cab floor shall be of skid resistant glass fibre reinforced plywood or approved equal. Cab shall be attached to a framed structure and form integral part with the drive mechanism located atop the cab.

Framed structure shall include guide rollers and safety hooks to ensure positive engagement of the rack and pinion to prevent cab disengagement in case of roller failure.

1.2.4 Buffers

i. Sufficient numbers of buffers of spring loaded/hydraulic type shall be fitted below the cab. The buffers shall be capable of stopping the cab without permanent damage or deformation to themselves or any other part of the equipment. The number of buffers shall be so fixed as to ensure proper sharing of impact loads by all of them.

1.2.5 Drive unit and safety Device

i. Drive unit located on the top of the cab shall be complete with Ac squirrel cage induction motor, reduction gear, drive pinion and an over speed governor. Drive unit shall incorporate an electric disc brake and an external manual brake release. The brake on the electric motor will be of the electromagnetic single disc self-adjusting type with the mechanical compression spring being held off by the electromagnet.

ii. The hoist shall be provided with a centrifugal brake to prevent accidental tripping of safety device when the cage shall be taken to the ground by gravity in case of power failure.

1.2.6 Power and Control

i. All electrical components furnished with the elevator shall be completely wired, energised and checked. Necessary power distribution arrangement shall be provided by the contractor to feed the electrical power to the elevator.

ii. All electrical control devices shall be in enclosures. Equipment furnished shall also include the following:

a) Momentary contact push button for raise lower control.

b) Reversing combination motor starter with a moulded case circuit breaker for the motor. Starter shall be equipped with three thermal overload relays for motor protection. Operating handle for the combination starter circuit breaker shall be accessible from inside the cab and shall also serve as an emergency stop switch.

c) Electrical and mechanical interlocks on cab access door and landing level enclosure doors.

d) Over travel protection, emergency stop push button, over speed governors.

e) All electrical and mechanical interlocks on cab access door and landing level enclosure doors, phase reversal protection shall be provided.

f) An alarm push button shall be provided in the cage connected to a battery-operated alarm at the elevator base. Simultaneous alarm shall also sound at the plant control room in the event of any fault in the stack elevator for which one potential free contact shall be provided in each elevator for audiovisual alarm in PCR for “Stack Elevator fault” indication.

g) Reverse phase relay connected to prevent operation of the cab with improper phase rotation or failure in any phase in the power supply.

h) Continuous duty electric torque motor recoil cable reels as required to maintain electrical power service to all elevator electrical components throughout the limits of travel.

i) One auxiliary panel shall be furnished and mounted on the grade level enclosure. Panel shall be equipped with a main ‘ON-OFF’ isolating switch, main contactor, relays, control transformer and fuses, tone frequency transfer, terminal blocks and all other accessories required for normal operation of the elevator.

j) One main control panel shall be furnished and mounted on the top of the cab. Panel shall be equipped with necessary, equipped like rectifier, battery, charger, tone frequency receiver, contactors, MCBs, control transformer and fuses, thermal overload relays, and all other equipment and accessories required for normal operation of the elevator.

k) Control cabinets shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet steel used shall be cold rolled and at least 2.0 mm thick and properly braced to prevent wobbling. Degree of protection of the control cabinets shall be IP-52 as per IS:2147. Control cabinets shall be provided with hinged door(s) with padlocking arrangement. All doors, removable covers and plates shall be gasket all around with neoprene gaskets, louvers, when provided, shall have screeners and filters. The screens shall be of fine wire mesh made of brass or GI wire. Suitable cable gland plate shall be supplied fitted on to this gland plate. All cable glands shall be screwed on type and made of brass.

l) Each motor to be controlled from the control cabinet shall be provided with 3 pole isolating switch. HRC fuses, contactors of AC4 duty class with thermal overload relays with single phasing preventer and other equipment required for satisfactory control motor. The isolating switch and contractor shall be rated at least 20% more than the connected motor full load current. Motors of 0.2 KW and above shall be rated for 415 V 3 Phase and below 0.2 KW will be 240 V single phase supply.

m) The controllers and resistors for motors shall conform to IS-8544 (latest edition) and IS-2959 (latest edition) and shall be continuously rated for 150% full load current of the motor. Switches shall be hand operated, air breaker heavy duty, quick make, quick break type conforming to IS-4064. The rating of switch shall be so chosen as to get complete protection by associated O/L relay or fuse under all normal / abnormal conditions such as full load, overload, locked rotor, short circuit. The incoming power supply isolating switch shall

be inter-locked with the control cabinet door so as to prevent opening of the door when the switch is closed. Device for bypassing the door interlock shall also be provided. Switch handle shall have provision for locking in both fully open and fully closed positions.

n) All fuses shall be of the HRC cartridge type mounted on plug in type of fuse base having a prospective current rating of not less than 80 KA. Fuses shall be provided with visible operation indicators to show that they have operated. All accessible live connections shall be adequately shrouded and it shall be possible to change fuses with the circuit alive without danger of contact with live metal.

o) Contractor shall provide dry type transformers with class B insulation for control power supply, lighting and space heating. Control supply will be 240 V AC. Transformer for control supply shall be provided with a control tap at 110 V, which will be earthed. Power and control supply to individual drives and users shall be distributed with separate isolating switches and primary and secondary fuses.

p) All push buttons shall be of push to actuate type having 2 “NO” and 2 “NC” self reset contacts. They shall be provided with integral escutcheon on plate engraved with their functions. Push button contacts shall be rated for 5 Amp at 415 V AC and 1 Amp. Inductive breaking at 250 V, DC. Mushroom type emergency push button to open the main contactor shall be provided in the operator’s cabin and two on the bridge platform within easy reach indicating lamps shall be of the filament type and low watt consumption lamps shall be provided with series resistors.

q) Strip type space heaters of adequate capacity shall be provided inside in each cabinet.

r) Control cabinets shall be supplied completely wired. All wiring shall be carried out with 650 V grade PVC insulated, stranded conductors. Power circuits shall be wired with stranded aluminum conductors of adequate sizes to suit the rated circuit shall be wired with stranded copper conductors of sizes not small than 1.5 Sq.mm. Control circuits shall be isolated from power circuits.

s) Cab shall be controlled by a semi-automatic floor selection control system. Cab shall be furnished with 240 Volt grounding type receptacle, emergency alarm push button with a normally open contact rated 0.5 ampere at 220 VDC volts, indicating light, limit switches, and all other necessary control devices required to ensure safe and continuous cab operation. One trailing cable shall connect the cab main control panel to the auxiliary panel at ground level. Cable shall supply the cab with all power requirements. Cable guides shall be installed at every 6 metres to avoid entanglement of this cable. Control signals between the auxiliary panel at ground level and the main control panel on the cab. Will be provided with the tone frequency receiver. However control and interlocks from the landings shall be connected to the auxiliary panels located at ground level through fixed armoured cables. The power and control cables and training power cables shall be FRLS type.

t) Each landing assembly shall include a limit switch for door interlock and push button control station installed and wired to a landing junction box.

u) Cable trolley with cable guides for recoil of cable on to cable reel to maintain electrical power service to all elevator components through out the limits of travel.

v) Contractor shall furnish, install, and connect a system equipment ground to the Owner's existing chimney ground system. System equipment ground shall electrically connect panels and junction boxes, which contain electrical devices, motors, and elevator platforms and support structure. Raceway system shall not be considered as an equipment ground.

w) All enclosures containing electrical devices shall be provided with 240 Volt, single-phase space heaters with adjustable thermostat control.

x) All power cables and race way shall be furnished and installed by the Contractor for interconnection of the main control panel, auxiliary panel and landing junction boxes etc. Conductors included in the cable shall be as required to energise all electrical equipment furnished with the elevator. Transmission of alarm signals is done by means of tone frequency equipment. Hence communication conductors are not required.

1.2.7 Electric Motor

i. Elevator drive motor shall be squirrel-cage induction type designed and fabricated to conform to the requirements indicated below.

ii. Motor shall be designed for operation at the required speed: 415 Volts, 3 phase, 50 hertz. And shall be suitable for full voltage starting, S4 duty class as per IS-4722 with CDF of 25% and maximum number of 120 starts per hour in 55 Deg. C ambient temperature. Motor shall be tested at the factory to determine that it is free from electrical or mechanical defects.

1.2.8 Raceway

i. General

a) Complete raceway system for the elevator shall be furnished and installed in accordance with this section and the Contractor's shop drawings as reviewed and accepted by the Engineer-in-Charge. The Contractor shall provide drawings for acceptance showing the routing of conduit and wiring for the control circuits associated with the elevator.

b) Raceway system is defined to include conduit and all related materials and devices required to support, secure and provide a complete system for support and protection of electrical cable and wiring.

ii. Materials

a) Raceway shall be rigid galvanized steel conduit, provided in accordance with IS-1653 (latest edition).

b) Steel conduit, couplings, and elbows shall be hot-dip galvanized rigid mild steel. Each length of threaded conduit shall be complete with a coupling on one end and a thread protector on the other. Thread protector shall have sufficient mechanical strength to protect the threads during normal handling and storage. Flexible conduits shall be plastic jacketed, liquid tight galvanized steel.

c) Galvanized iron or galvanized cast steel fittings shall be used with galvanized steel conduit. Fittings installed outdoors or in damp locations shall be sealed and gasketted. Outdoor fittings shall be of heavy cast construction.

1.2.9 PVC Insulated FRLS Cable

i. Materials

a) Electrical part of this specification shall be referred for FRLS cable. Unless specified otherwise, Contractor shall submit to the Engineer-in-Charge four copies of the manufacturer's test report on each cable furnished. Conductor accessories including terminal materials like glands, lugs etc. makers, tying materials and cable support shall be furnished and installed. Wire termination materials for conductors 10 Sq. mm and larger shall be pressure or bolted type. Terminals for conductors smaller than 10 Sq. mm shall be an insulated pressure connection in the shape of a ring.

ii. Installation

a) Power and control cable shall be routed as required by the drawings. Cables pulled into the wrong conduit or cut too short shall be replaced. Cables removed from one conduit shall not be installed in another conduit.

1.2.10 Earthing

i. General

a) Earthing system furnished and installed and include a complete earthing system for the elevator. Earthing equipment and materials shall be furnished and installed in accordance with the reference codes and standards these specification and the contractor's shop drawings as reviewed and accepted by the Engineer-in-Charge.

ii. Materials

a) The earthing of all electrical items being supplied by the Bidder shall be in his scope. For earthing the various equipment, conductor sizes shall be as listed below:

- MCCs Motor above 90 KW : 50 x 6 Sq.mm G.I. flat

- Motors above 30 KW, upto 75 KW and lighting panel/ control panels/auxiliary panels : 25 x 6 Sq. mm G.I. flat
- Motor above 5 KW upto 30 KW : 25 x 3 mm G.I. flat
- Motors upto 5 KW and misc. : 8 SWG GI wire
- Small item like conduits,
- Junction boxes etc..

# SUB-SECTION - A6

# STACK ELEVATORS

1.01.00 **ELEVATOR PARTICULARS**

i) Load Carrying Capacity in Kg
ii) Type of loading for which the stack elevator is designed
iii) Type of stack elevator
iv) Rated Load in Kg
v) Speed in metre/minute
vi) Chimney height in metre
vii) Total travel height in metre
viii) No. of floors to be served
ix) Elevations of the floors to be served
x) Method of control
xi) Details of indicators and control
xii) Weight of cab complete without load in Kg
xiii) Weight of hoist cab in Kg
xiv) Efficiency of Elevator

1.02.00 GROUND ENCLOSURE

i) Size of the enclosure (Length x breadth x height)
ii) Material of construction
iii) Size of landing entrance
iv) Method of door operation
v) Electrical & mechanical interlocking Of the door provided.
vi) Method of fixing enclosure to chimney
vii) Any other details not covered above

1.03.00 LANDING ENCLOSURES

viii) Size of the enclosure (Length x breadth x height)

ix) Material of construction

x) Size of landing entrance

xi) Method of door operation

xii) Electrical & mechanical interlocking
Of the door provided.

xiii) Method of fixing enclosure

xiv) Any other details not covered above

1.04.00 MAST

i) Material of mast

ii) Section of mast

iii) Size of each piece of mast

iv) Method of fixing of mast

v) Type of mast

1.05.0 CAB

i) Internal size
(Length x breadth x height)

ii) Material of construction

iii) Type of floor

iv) Size of the cab door

v) Method of operation of cab door

vi) Electrical & mechanical interlocking provided

vii) Escape hatch, electrically interlocked

viii) Guide roller and safety hooks provided

ix) Arrangement of light/fan inside the cab.

x) Indicators & controls inside the cab.

1.06.00 ELEVATOR DRIVE UNIT

i) Location of drive unit

ii) Name of components of drive unit

1.07.00 DETAILS OF ELECTRIC MOTOR

i) Manufacturer
ii) Equipment driven by motor
iii) Type
iv) Frame size, type & designation
v) Maximum load considered for
Sizing of motor
vi) Margin considered for sizing motor
vii) Rated power in KW
viii) Service factor
ix) Speed in rpm
x) Rated voltage in V
xi) Current at rated voltage
- Full load
- Locked rotor

xii) Insulation class
xiii) Type of bearing and type of lubricant
xiv) Space heater rating
xv) Duration considered for specified
Ambient temperature
xvi) Applicable standard to which motor conforms
xvii) Degree of protection
xviii) Efficiency at rated output
xix) Power factor
xx) Type of mounting

1.08.00 DETAILS OF REDUCTION GEAR

i) Make
ii) Material of the gears and hardness in BHN
iii) Type of gear
iv) Gear ratio

v) Gear power transmitted

vi) Input and output speed

1.09.0 DETAILS OF DRIVE AND PINION

i) Material

ii) Hardness

iii) Fixing arrangement

1.10.0 DETAILS OF RACK

i) Material

ii) Hardness

iii) Fixing arrangement

1.11.00 SAFETY DEVICE

i) Make

ii) Type of safety device

iii) Speed at which the safety device
Come into action

iv) Method operation

v) Other details

vi) Remote control for testing
The safety device

1.12.00 BRAKES

i) Manufacturer

ii) Types of brakes provided

iii) Method of operation

iv) Interlocking if any

v) Electromagnetic brake and external
Manual brake release

vi) Degree of protection

1.13.00 CENTRIFUGAL BRAKE

i) Make

ii) Details

iii) Remote control for testing

The safety device provided.

iv) Any other details of drive unit

Not covered above.

1.14.00 BUFFERS

i) No. and location of the buffers provided

ii) Type of buffers

iii) If the buffers are spring type

Furnish the following:

- Diameter of the spring in mm
- Max. Compression under extreme cond.
- No. of spring coil
- Sectional dimension
- Material of spring
- Compression /unit load

1.15.00 POWER CABLES Fixed Trailing

i) Manufacturer

ii) Type and material

iii) Rated voltage

iv) Rated current

v) Type of insulation

vi) No. of strands

vii) No. of cores

viii) Short circuit current rating

ix) Resistance per 1000 metres

x) Applicable standards

1.16.00 CONTROL CABLES

xi) Manufacturer
xii) Type and material
xiii) Rated voltage
xiv) Rated current
xv) Type of insulation
xvi) No. of strands
xvii) No. of cores
xviii) Short circuit current rating
xix) Resistance per 1000 metres
xx) Applicable standards

1.17.00 CONDUITS/ACCESSORIES AND FITTINGS

i) Material
ii) Manufacturer
iii) Applicable standard

1.18.00 CONTACTORS

i) Make
ii) Type
iii) Applicable standards
iv) No. of poles
v) Rated voltage
vi) Rated frequency
vii) Rated current
viii) Closing coil
- Rated voltage
- Current consumption

- Power consumption in KW
- Insulation class for electromagnet

ix) Rated duty
- Rated insulation category
- No. of operations per hour
- Rated breaking capacity
- Rated making capacity
- Short time rating in sec

ix) Limits of operation
- Supply voltage variations (%)
- Supply frequency variations (%)
- Drop out voltage (%)
- Min. pick up voltage (%)

x) Thermal overload relay setting range available

xi) Auxiliary contacts
- Numbers
- Current rating (Make and break)

xi) Rated utilization category as per IS 2459

xii) Max. recommended back up HRC fuse size

1.19.00 FUSES

i) Make

ii) Type

iii) Continuous current

iv) Rated voltage

v) Rated frequency

vi) Rupturing capacity

vii) Mounting details

viii) Fixing and removing arrangement

ix) Visual indication for fuses

x) Applicable standards

1.20.00 INDICATING LAMPS

i) Make
ii) Type
iii) Rated voltage
iv) Rated power consumption in Watt
v) Permissible voltage variation
vi) Series resistance provided

1.21.00 PUSH BUTTONS

i) Make
ii) Type
iii) Rating
- Voltage
- Continuous current

iv) No. of aux. Contacts
- Normally open
- Normally closed

v) Contact rating
vi) Colours
vii) Mounting arrangement

1.22.00 OVER TRAVEL LIMIT SWITCH

i) Make
ii) Type
iii) Material of contacts
iv) Contact rating
v) Numbers furnished

1.23.00 CONTROL TRANSFORMER

i) Make
ii) Type
iii) Output rating (VA)
iv) Ratio

v) Class of insulation

vi) Max. temp rise of winding over
Specified ambient temperature.

vii) One minute power frequency test voltage

viii) Applicable standards

1.24.00 CIRCUIT BREAKER AND ISOLATOR

i) Make

ii) Type

iii) Current rating in amps

iv) Interruption duty

v) Max. breaking capacity

vi) Operating voltage of tripping and closing coils

vii) Max. permissible variation of operating voltage

1.25.00 RACEWAY

i) Raceway as per specification

ii) Material of

- Indoor fittings
- Outdoor fittings
- Raceway support
- Junction boxes

1.26.0 EARTHING

i) Earthing conductor

- Size
- Material

ii) Material of earthing cable

iii) Clamps. Bolts, washers, nuts and another
Hardware of iron steel are galvanized.

1.27.00 MOTOR STARTER

i) Make & Size

ii) Rating]

iii) Mechanically latched type

iv) Single phase prevention feature provided

v) Degree of protection

1.28.00 DETAILS OF CONTROL PANELS

i) No. of panels

ii) Type of enclosures (Degree of protection)

iii) Thickness of sheet metal

iv) Painting

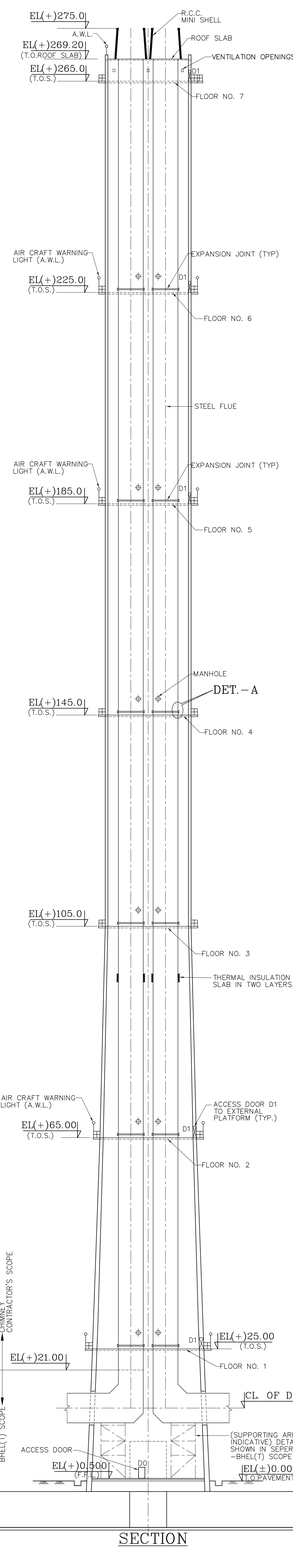
- Colour
- Finish

v) Cable entry

vi) Manufacturer

DRAWING NO. PE-DG-411-620-C001

NORTH

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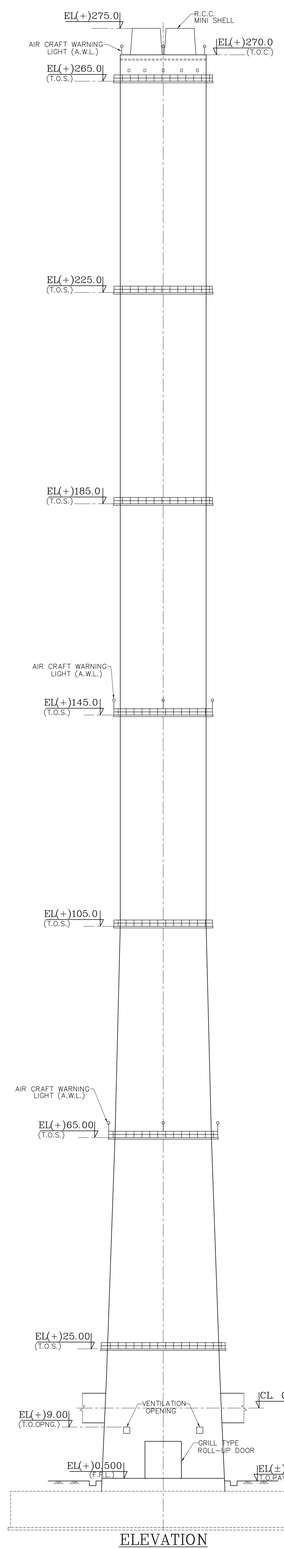
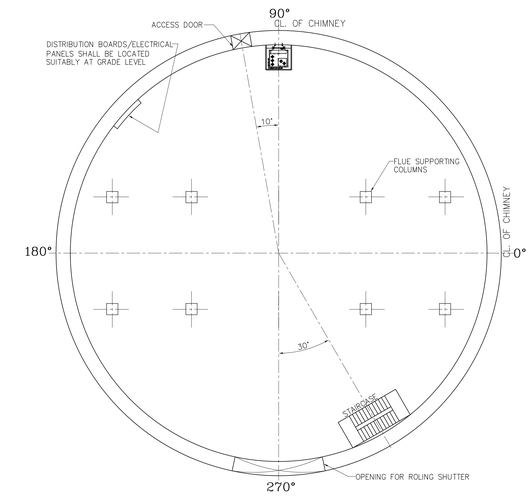
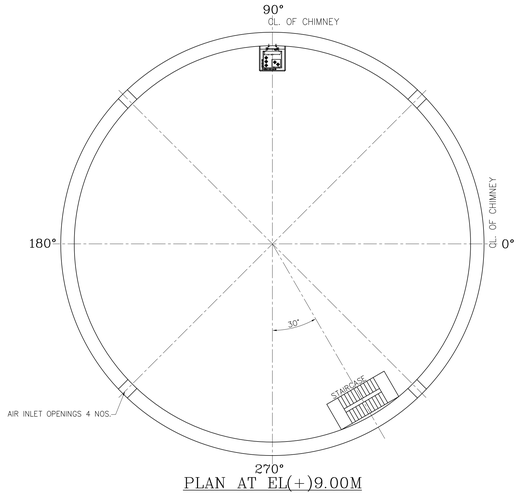


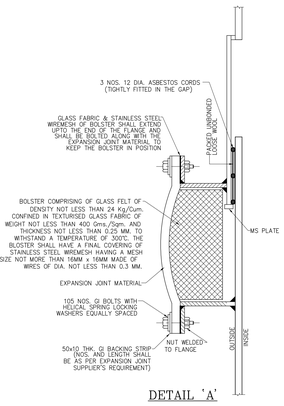

ELEVATION



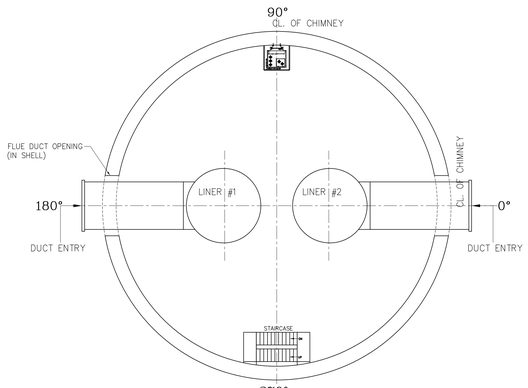

PLAN AT EL(±)0.00M



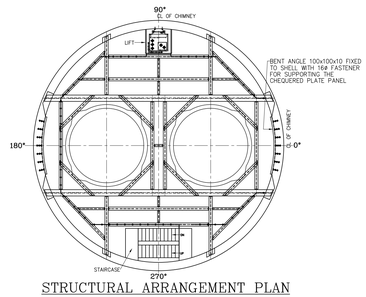

PLAN AT EL(+)9.00M



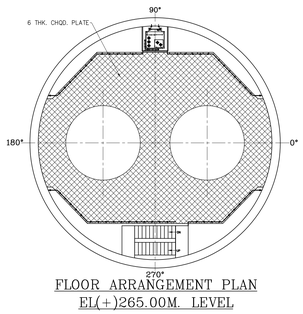

DETAIL 'A'



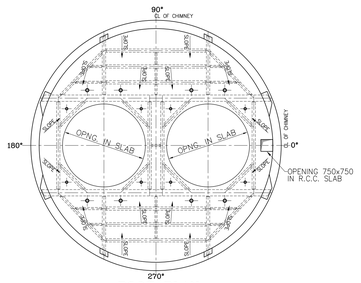

PLAN AT DUCT ENTRY LEVEL




STRUCTURAL ARRANGEMENT PLAN
EL(+)265.00M. LEVEL




FLOOR ARRANGEMENT PLAN
EL(+)265.00M. LEVEL




ROOF PLAN
(T.O.C. = EL+269.200 M.)

# FOR TENDER PURPOSE ONLY

NOTES: –

1. ALL DIMENSIONS ARE IN MILLIMETRES AND LEVELS ARE IN METRES.
2. COMPLIANCE WITH STANDARDS SHALL RELATE TO LATEST PUBLISHED EDITIONS.
3. EL. ±0.00 CORRESPONDS TO R.L. 107.00 M.
4. THE OTHER COMPONENTS OF THE CHIMNEY INCLUDE ROLL UP DOORS, PERSONNEL ACCESS DOORS, HAND RAILS, HOOD HATCH, LINER TEST PORTS, NON METALLIC EXPANSION JOINTS, RAIN WATER DRAINAGE SYSTEM, VENTILATION OPENINGS, ELECTRICAL POWER SUPPLY DISTRIBUTION BOARDS, LIGHTING PANELS, SOCKET OUTLETS, POWER AND CONTROL CABLING, RACEWAY SYSTEM, STAIR AND PLATFORM LIGHTING, LIGHTNING PROTECTION & GROUNDING SYSTEM, COMMUNICATIONS SYSTEM ETC. AND SHALL BE PROVIDED AS PER TECHENICAL SPECIFICATIONS.
5. FOR STANDARD NOTES & DETAILS FOR RCC WORKS REFER APPROVED DRG. NO. PE–DG–411–600–C001.
6. FOR STRUCTURAL DETAILS, WELDING, HANDRAILING ETC. REFER APPROVED DRG. NO. PE–DG–411–600–C002.
7. AIRCRAFT WARNING LIGHT (A.W.L.) SHALL BE PROVIDED TO MEET THE REQUIREMENT OF RELEVANT STANDARD STATUTORY BODY.

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# CHIMNEY

## Results of Field and Laboratory Tests

| BOREHOLE / TRIAL PIT NO. | DEPTH (m) | TYPE OF SAMPLE | SPT (N Value ) | | | | DENSITY ($g/cm^3$) | | WATER CONTENT (%) | PARTICLE SIZE (%) | | | | ATTERBERG'S LIMITS | | | | SOIL | | SPECIFIC GRAVITY | STRENGTH TEST | | | CONSOLIDATION TEST | | | | | SWELL TEST | | COMPACT | | CALIFORNIA BEARING RATIO (%) | RELATIVE DENSITY | PERMEABILITY (m/hr) | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | BULK | DRY | | GRAVEL | SAND | SILT | CLAY | Liquid | Plastic | Plasticity Index | Shrinkage | IS CLASSIFICATION | DESCRIPTION | | Type | Cohesion 'c' ($kg/cm^2$) | Angle of Shearing Res. 'Φ' (deg | Initial Void Ratio '$e_o$' | Preconsolid. Press. 'Pc' ($kg/cm^2$) | Compression Idex '$C_c$' | Co. of Vol. Comp. 'mv' ($cm^2/kg$) | Co. of Consolid. 'Cv' ($cm^2/min$) | Swelling Pressure ($kg/cm^2$) | Free Swell Index (%) | Max. Dry Dendity ($g/cm^3$) | Optimum Moisture Cont. (%) | | | | |
| 26 | 1.0 | SPT | 4 | 5 | 6 | 11 | | | | 0 | 31 | 32 | 38 | 40 | 20 | 20 | | CI | | 2.55 | | | | | | | | | | | | | | | |
| 26 | 2.0 | UDS | | | | | 1.99 | 1.53 | 30.49 | | | | | | | | | CI | | | UCC | 2.23 | 0 | | | | | | 0.45 | 80 | | | | | | |
| 26 | 3.0 | SPT | 6 | 9 | 11 | 20 | | | | 4 | 20 | 30 | 46 | 43 | 21 | 22 | | CI | | 2.56 | | | | | | | | | 0.86 | 100 | | | | | | |
| 26 | 4.0 | UDS | | | | | 2.16 | 1.80 | 20.16 | | | | | | | | | CI | | | UU | 1.32 | 0 | | | | | | 0.50 | 60 | | | | | | |
| 26 | 5.0 | SPT | 9 | 18 | 28 | 46 | | | | 0 | 11 | 36 | 53 | 46 | 23 | 23 | | CI | | 2.57 | | | | | | | | | | | | | | | |
| 26 | 6.5 | UDS | | | | | | | | Soft Weathered Rock (Shale) | | | | | | | | | | | | | | | | | | | | | | | | | | |

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| BOREHOLE / TRIAL PIT NO. | DEPTH (m) | TYPE OF SAMPLE | SPT (N Value ) | | | | DENSITY ($g/cm^3$) | | WATER CONTENT (%) | PARTICLE SIZE (%) | | | | ATTERBERG'S LIMITS | | | | SOIL | | SPECIFIC GRAVITY | STRENGTH TEST | | | CONSOLIDATION TEST | | | | | SWELL TEST | | COMPACT | | CALIFORNIA BEARING RATIO (%) | RELATIVE DENSITY | PERMEABILITY (m/hr) | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | BULK | DRY | | GRAVEL | SAND | SILT | CLAY | Liquid | Plastic | Plasticity Index | Shrinkage | IS CLASSIFICATION | DESCRIPTION | | Type | Cohesion 'c' ($kg/cm^2$) | Angle of Shearing Res. 'Φ' (deg | Initial Void Ratio '$e_o$' | Preconsolid. Press. 'Pc' ($kg/cm^2$) | Compression Idex '$C_c$' | Co. of Vol. Comp. 'mv' ($cm^2/kg$) | Co. of Consolid. 'Cv' ($cm^2/min$) | Swelling Pressure ($kg/cm^2$) | Free Swell Index (%) | Max. Dry Dendity ($g/cm^3$) | Optimum Moisture Cont. (%) | | | | |
| 27 | 1.0 | SPT | 4 | 6 | 9 | 15 | | | | 0 | 67 | 27 | 6 | LP | LP | | | SC | | 2.6 | | | | | | | | | 30 | | | | | |
| 27 | 2.0 | UDS | | | | | 1.83 | 1.48 | 23.18 | | | | | | | | 11.87 | | | | CD | 0.17 | 27 | | | | | | | | | | | | |
| 27 | 3.0 | SPT | 9 | 12 | 13 | 25 | | | | 6 | 23 | 32 | 39 | 59 | 36 | 23 | | CI | | 2.55 | | | | | | | | | 0.40 | 50 | | | | | |
| 27 | 4.0 | UDS | | | | | 2.18 | 1.83 | 19.00 | | | | | | | | | | | | UU | 1.07 | 18 | | | | | | | | | | | | |
| 27 | 5.0 | SPT | 15 | 16 | 23 | 39 | | | | 0 | 8 | 32 | 60 | 93 | 45 | 48 | | CI | | 2.56 | | | | | | | | | | | | | | | |
| 27 | 6.5 | UDS | | | | | 2.00 | 1.66 | 20.20 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27 | 8.0 | | 34 | 39 | 48 | 87 | | | | Soft Weathered Rock (Shale) | | | | | | | | | | | | | | | | | | | | | | | | | | |

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| BOREHOLE / TRIAL PIT NO. | DEPTH (m) | TYPE OF SAMPLE | SPT (N Value ) | | | | DENSITY ($g/cm^3$) | | WATER CONTENT (%) | PARTICLE SIZE (%) | | | | ATTERBERG'S LIMITS | | | | SOIL | | SPECIFIC GRAVITY | STRENGTH TEST | | | CONSOLIDATION TEST | | | | | | SWELL TEST | | COMPACT | | CALIFORNIA BEARING RATIO (%) | RELATIVE DENSITY | PERMEABILITY (m/hr) | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | BULK | DRY | | GRAVEL | SAND | SILT | CLAY | Liquid | Plastic | Plasticity Index | Shrinkage | IS CLASSIFICATION | DESCRIPTION | | Type | Cohesion 'c' ($kg/cm^2$) | Angle of Shearing Res. 'Φ' (deg | Initial Void Ratio '$e_o$' | Preconsolid. Press. 'Pc' ($kg/cm^2$) | Compression Idex '$C_c$' | Co. of Vol. Comp. 'mv' ($cm^2/kg$) | Co. of Consolid. 'Cv' ($cm^2/min$) | Swelling Pressure ($kg/cm^2$) | Free Swell Index (%) | Max. Dry Dendity ($g/cm^3$) | Optimum Moisture Cont. (%) | | | | |
| 49 | 1.0 | SPT | 6 | 9 | 13 | 22 | | | | 3 | 42 | 30 | 25 | 42 | 25 | 17 | | SC | | 2.65 | | | | | | | | | | | | | | | |
| 49 | 2.0 | UDS | | | | | 2.14 | 1.85 | 15.61 | | | | | | | | | SC | | | UU | 0.80 | 0 | | | | | | 0.15 | 40 | | | | | | |
| 49 | 3.0 | SPT | 13 | 15 | 18 | 33 | | | | 0 | 26 | 33 | 41 | 65 | 37 | 28 | | CI | | 2.56 | | | | | | | | | | | | | | | |
| 49 | 4.0 | UDS | | | | | 1.91 | 1.58 | 21.13 | | | | | | | | | CI | | | UCC | 2.12 | 0 | | | | | | 0.25 | 60 | | | | | | |
| 49 | 5.0 | SPT | 19 | 34 | 42 | 76 | | | | 6 | 14 | 32 | 48 | 68 | 40 | 28 | | CI | | 2.56 | | | | | | | | | | | | | | | |
| 49 | 6.5 | UDS | | | | | 2.20 | 1.71 | 28.93 | | | | | | | | | CI | | | | | | | | | | | | | | | | | |
| 49 | 8.0 | SPT | | | | N>100 | | | | Soft Weathered Rock (Shale) | | | | | | | | | | | | | | | | | | | | | | | | | | | |

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| BOREHOLE / TRIAL PIT NO. | DEPTH (m) | TYPE OF SAMPLE | SPT (N Value ) | | | | DENSITY ($g/cm^3$) | | WATER CONTENT (%) | PARTICLE SIZE (%) | | | | ATTERBERG'S LIMITS | | | | SOIL | | SPECIFIC GRAVITY | STRENGTH TEST | | | CONSOLIDATION TEST | | | | | SWELL TEST | | COMPACT | | CALIFORNIA BEARING RATIO (%) | RELATIVE DENSITY | PERMEABILITY (m/hr) | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | BULK | DRY | | GRAVEL | SAND | SILT | CLAY | Liquid | Plastic | Plasticity Index | Shrinkage | IS CLASSIFICATION | DESCRIPTION | | Type | Cohesion 'c' ($kg/cm^2$) | Angle of Shearing Res. 'Φ' (deg | Initial Void Ratio '$e_o$' | Preconsolid. Press. 'Pc' ($kg/cm^2$) | Compression Idex '$C_c$' | Co. of Vol. Comp. 'mv' ($cm^2/kg$) | Co. of Consolid. 'Cv' ($cm^2/min$) | Swelling Pressure ($kg/cm^2$) | Free Swell Index (%) | Max. Dry Dendity ($g/cm^3$) | Optimum Moisture Cont. (%) | | | | |
| 50 | 1.0 | SPT | 4 | 4 | 8 | 12 | | | | 1 | 47 | 33 | 21 | 42 | 24 | 18 | | SC | | 2.63 | | | | | | | | | | | | | | |
| 50 | 2.0 | UDS | | | | | 2.08 | 1.87 | 11.25 | | | | | | | | | SC | | | CD | 0.15 | 29 | | | | | | 0.60 | 50 | | | | | |
| 50 | 3.0 | SPT | 6 | 10 | 16 | 26 | | | | 5 | 50 | 29 | 16 | 38 | 22 | 16 | | SC | | 2.65 | | | | | | | | | | | | | | |
| 50 | 4.0 | UDS | | | | | 2.10 | 1.91 | 9.83 | | | | | | | | | SC | | | CD | 0.13 | 30 | | | | | | 0.15 | 45 | | | | | |
| 50 | 5.0 | SPT | 7 | 10 | 51 | 61 | | | | 0 | 20 | 32 | 48 | 75 | 42 | 33 | | CI | | 2.56 | | | | | | | | | | | | | | |
| 50 | 6.5 | UDS | | | | | | | | Soft Weathered Rock (Shale) | | | | | | | | | | | | | | | | | | | | | | | | |

***Type of Sample***

| | |
|---|---|
| DS | Disturbed Soil Sample |
| UDS | Undisturbed Soil Sample |
| RMS | Remoulded Soil Sample |
| WS | Water Sample |

***Type of Strength Tests***

| | |
|---|---|
| UCC | Unconfined Compression Test |
| VST | Vane Shear Test |
| Tuu | Unconsolidated undrained triaxial test |
| Tcu | Consolidated Undrained triaxial test with pore pressure |
| Tcd | Consolidated drained triaxial test |