



# भारत हेवी इलेक्ट्रिकल्स लिमिटेड

(भारत सरकार का उपक्रम)

## BHARAT HEAVY ELECTRICALS LIMITED

(A Govt. of India Undertaking)

TCN - 06

Ref: PSER:SCT:PAL-C987:TCN-06

Date: 28-04-2009

Sub	Tender change notice (TCN) 06.	
Job	Civil, structural, architectural work including foundations/ superstructure of various plant equipments/ systems/ facilities, non-plant buildings/ facilities, misc civil work, switch yard civil work etc of unit # 1 & 2 of 726.6 MW Gas based CCPP at Palatana, Udaipur, Tripura.	
Ref	1.0	Tender no PSER:SCT:PAL-C987:09.
	2.0	BHEL's NIT, vide reference no PSER:SCT:PAL-C987:1718, dated 23-03-09.
	3.0	BHEL's TCN-01, vide reference no PSER:SCT:PAL-C987:TCN-01, dated 08-04-09.
	4.0	BHEL's TCN-02, vide reference no PSER:SCT:PAL-C987:TCN-02, dated 15-04-09.
	5.0	BHEL's TCN-03, vide reference no PSER:SCT:PAL-C987:TCN-03, dated 18-04-09.
	6.0	BHEL's TCN-04, vide reference no PSER:SCT:PAL-C987:TCN-04, dated 23-04-09.
	7.0	BHEL's TCN-05, vide reference no PSER:SCT:PAL-C987:TCN-05, dated 24-04-09.
	8.0	All other pertinent issues till date.

With reference to above, following points/ documents, relevant to tender, may please be noted & complied with while submitting offer.

- 1.0 Additional technical specification as per attached Annexure-A.1, Annexure-A.2 & Annexure-A.3.
- 2.0 Specification for store under switch yard part as per attached Annexure-B.
- 3.0 Revised Price Schedule, Volume-III A, Rev-2 is attached. Bidder shall quote as per this revised Volume-III A, Rev-2 only.
- 4.0 Revised 'No deviation certificate' format as per enclosed Annexure-2. Bidder shall submit 'No deviation certificate' along with offer as per enclosed format.
- 5.0 All other terms & conditions shall remain unchanged.

Based on above, offer shall be submitted by due date.

Thanking you,

Yours faithfully,  
for BHARAT HEAVY ELECTRICALS LTD

DGM (SCT)

Encl: As above.

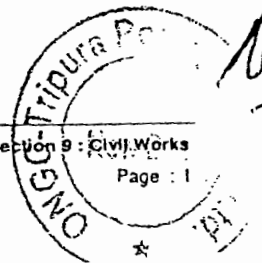
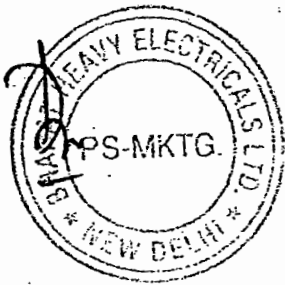
पावर सेक्टर पूर्वी क्षेत्र (मुख्यालय)

POWER SECTOR EASTERN REGION, DJ-9/1, SALT LAKE CITY, KOLKATA - 700 091

फैक्स/Fax : (033) 23211960 फोन/Phone : बोर्ड/EPABX : 23211691/ 23211798/ 23211796

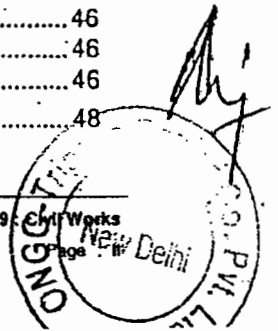
SECTION 9

CIVIL WORKS

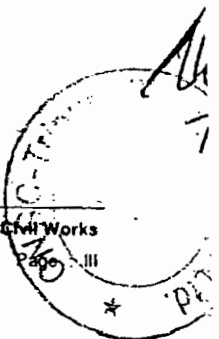
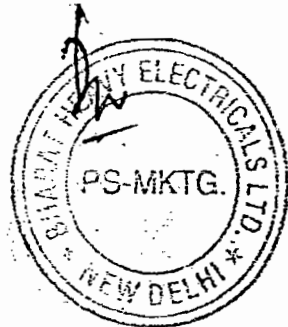


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## 9.0 CIVIL WORKS

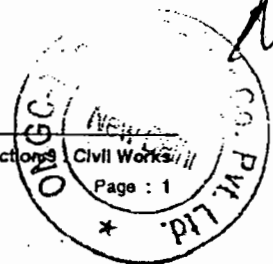
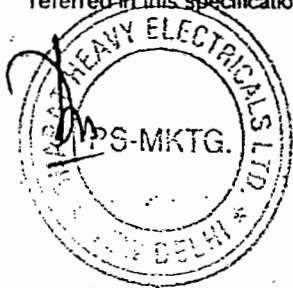
## 9.1 GENERAL

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

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

The design and construction specifications included in this section are intended to cover the general design and construction quality requirements. It is not intended to cover the minute details. The Standard Technical Specifications for Construction included under Section 8.5, cover the quality and workmanship requirements for the various materials and types of work. The specific material and type of work to be adopted for this project are specified in Section 8.4 hereunder. In case the same is not specified, the Contractor shall indicate in his offer, the material and specification he proposes to adopt for such works and get the same approved. In case construction requirements for any item specified in Design Specifications are not covered in the Construction Specifications, the manufacturer's specification / recommendations, other International Standards or good engineering practice (but not contradictory or inferior to Indian Standards), as approved by Owner's Engineer, shall be followed. In case of any contradiction between the provisions of Section 8.5 and Section 8.4, the more stringent of the two shall govern. In all cases, the decision of the Owner shall be final & binding.

Any reference to unit rates, Schedule of Item, Bill of Quantities, etc. If found, in the Standard Technical Specification under Section 8.5 shall be considered as not applicable, as this is an EPC tender on lump sum basis. Units of linear dimensions, sizes etc. referred in this specification shall be in millimeters (mm) unless otherwise specified.



**9.2 SCOPE OF WORK****9.2.1 General**

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

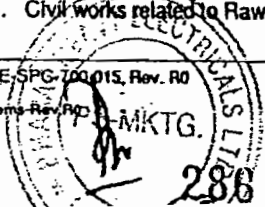
The scope shall include other related works although they may not be specifically mentioned in the subsequent clauses and all such incidental items not mentioned, but are necessary for completion of the work as a whole. The Contractor shall supply all materials including cement and steel. Each consignment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

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

The intending Bidders are advised to visit the site to have a first hand information about the site conditions such as access to site, access for construction and erection, clearance available, availability of material (e.g. aggregate, sand, bricks etc.) and all other relevant details before submission of tender. Non familiarity with the site conditions will not be considered a reason either for extra claims nor for not carrying out work in strict conformity with time schedule, drawing and specifications.

**9.2.2 Buildings, Structures and Facilities covered in the scope**

1. Patrol road and watch towers along the boundary wall.
2. Chain link fence and Gate between plant and Non-plant building
3. Fencing around Switchyard and Transformer yards including Gates
4. Site Grading
5. Plant Access Road from the Pallatana-Kakarban road near the entrance of the project site at the North west corner including Access Roads to River Water Intake
6. Plant Internal Roads and paved areas
7. Storm Water Drainage System
8. Gas Turbine and Generator Buildings
9. Gas Turbine Foundations
10. Gas Turbine Area Equipment Foundations
11. HRSG Foundations
12. Main Stack foundation.
13. STG Building
14. Steam Turbine Foundations
15. Switchgear and Control Buildings
16. Transformer Foundations
17. Switchyard Structures and Foundations
18. Switchyard Control Room
19. Fuel Gas Conditioning Station
20. Fuel Gas Compressor Station
21. Black Start and Emergency DG Set Buildings
22. CW Pump houses
23. Cooling Towers
23. River Water Intake and Pumphouse
24. Civil works related to Raw Water Pipeline and Effluent disposal line



25. Raw Water and Fire Water Reservoirs
26. Raw Water Pump House
27. Clarifiers
28. Clarified Water Storage Tank
29. Clarified Water and Fire Water Pump House
30. Service Water and Potable Water overhead tank
31. DM Plant
32. Chemical Laboratory
33. Chemical Storage Building
33. HRSB Blowdown sump
34. Central Monitoring Basin
35. Pipe and Cable Racks
36. Pipe and Cable Trenches
37. Workshop
38. Stores
39. Fire Station
40. Fire Drill Tower
41. Administrative Building
42. Canteen
43. Training Centre
44. Hostel
45. Medical Centre
46. Gate / Security House
46. Site offices for Owner's and Owner's Engineers' use.
47. Two Wheeler Parking Area
48. Car Parking Area
49. Cycle Stand
50. Sewage Disposal System.
51. Oily Water System
52. Landscaping including sprinkler type irrigation using treated effluent from sewage disposal system in areas under this specification
53. Any other buildings / structures required from system considerations.

#### Owner supplied Information & Exclusions

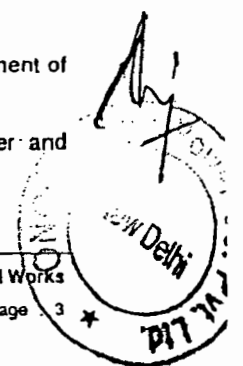
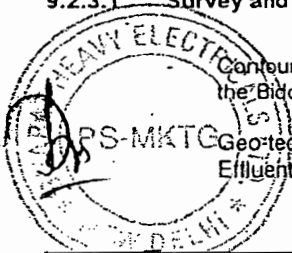
- The Topographical survey conducted by the owner and Geo-technical Report on the investigations carried out by Owner shall be made available to intending bidders for information with no liability on the accuracy of the information furnished in the reports.
- The Site formation levels proposed to be adopted shall also be provided. If the Bidders propose to modify the same then they can submit such information during the start of Engineering activities of the Project for the approval of Owner/Engineer.
- Owner shall construct the Boundary wall including the main Entry gate along the periphery of the project site including finalized formation levels to be adopted in different areas.

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

##### 9.2.3.1 Survey and Investigation

Contour survey of the Power Plant (if required to be conducted on the requirement of the Bidder) and River Water and Effluent disposal pipe line routes

Geo-technical Investigations within the Power Plant, along the River Water and Effluent Disposal Pipeline Route and in River Intake & Outfall Areas.



- Hydro geological studies and Data collection for locating, deciding the type of River Intake and designing the same.

### 9.2.3.2 Design and Engineering

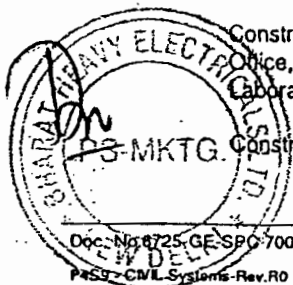
- Preparation and submission of design calculations and construction drawings and getting the same approved by the Engineer / Owner's representative.
  - a) Geo-engineering - Interpretation of geo-technical investigation report and selection of design parameters & foundation type & details in consultation and with approval of the Owner.
  - b) Design criteria for Civil, Structural and Architectural works.
  - c) Design Calculations for road and drains
  - d) Structural calculations for structures and foundations.
  - e) Hydraulic calculations for drains.
  - f) Static and Dynamic analysis for machine foundations
  - g) General Arrangement and Reinforcement drawings for concrete works
  - h) Architectural and joinery details for buildings
  - i) Layout and details for outdoor facilities - Roads, Paving, drainage, sewerage, cable / pipe trenches, duct banks etc.
  - j) General Arrangement and fabrication drawings for steel structures
  - k) Architectural floor plans including conceptual interior/ equipment and furniture arrangement, elevations, cross sections and perspective view in colour of all buildings (ie) for GT St common control room, facility buildings etc., including provision of natural light for GT & ST buildings. Bidder shall submit two different schemes alongwith a report elaborating the underlying philosophy of the proposed architectural concepts.
- Preparation and submission of design and drawings for statutory approvals from local Municipal / Panchayat authorities, Factory Inspector, Civil Aviation Authorities and other authorities, as applicable.
- Obtaining necessary details, permission and approvals from statutory authorities for carrying out the work. Owner will issue necessary authorization letter and extend necessary help for the above to the extent possible.

### 9.2.3.3 Construction

- Construction of, Fences and Gates
- Clearing of the site and site grading of the Power plant area to the finished ground level.

Construction of temporary buildings and structures for Contractor's use, such as Site Office, Cement Godowns, Storage yards, Canteen, Construction Material Testing Laboratory and other facilities as required.

Constructs of site offices for Owner's & Owner's Engineers' use.

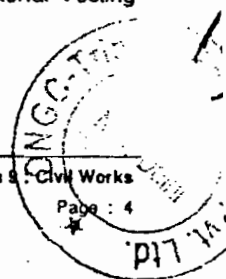


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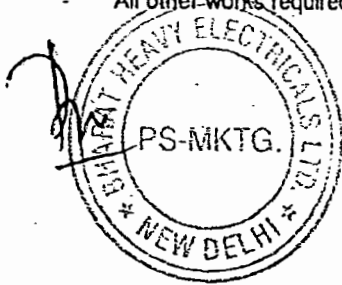
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Part IV, Section 9 - Civil Works

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- Construction of roads, peripheral walkways, drainage, sewerage, culverts, bridges, duct banks, signages, etc., within the Power Plant.
- Earthwork in excavation including rock quarrying/blasting, identifying borrow pits, transportation of soil from borrow pits, backfilling, disposal of excavated soil to designated areas within and outside the plant boundary etc. Archeological findings, if any, shall be reported to the Owner.
- Installation of trial piles, test piles and permanent working piles if required as per Geo-technical Report and its recommendations / interpretations.
- Pre-constructional Anti-termite treatment as specified.
- Civil, Structural and Architectural and finishing works for all buildings and structures.
- Sanitary and plumbing works for all buildings.
- Construction of all foundations and structures in RCC and steel work for all the buildings and facilities of the Power Plant.
- Construction of all equipment and machine foundations
- Construction of River Intake, River Water Pump House and River Water Pipeline upto plant (outside Power Plant boundary) as well as Effluent Disposal Pipeline from the Power Plant to the river.
- All other works required for completion of the project in all respects.



**9.3 DESIGN CRITERIA, SPECIFIC TECHNICAL REQUIREMENTS AND FUNCTIONAL REQUIREMENTS**

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

**9.3.1 Design Criteria - Codes and Standards**

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

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

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

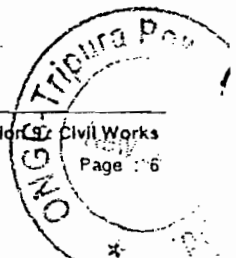
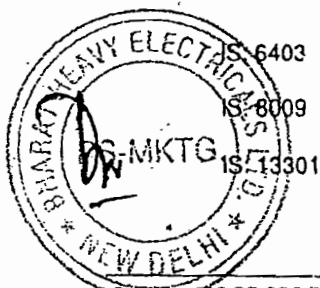
The Codes and Standards listed below are applicable for the design of structures and buildings in general. Codes and Standards applicable for specific design and construction are listed elsewhere in respective sections.

**9.3.1.1 General**

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

**9.3.1.2 Foundations**

- IS: 1080 Code of practice for design and construction of shallow foundations in soils (other than raft, ring and shell).
- IS: 1904 Code of practice for structural safety of building foundations.
- IS: 2950 Code of practice for design and construction of raft foundations.
- IS: 2974 Code of practice for design and construction of machine foundations.
- IS: 4091 Code of Practice for Design and Construction of Foundations for Transmission Line Towers and Poles.
- IS: 6403 Code of Practice for determination of bearing capacity of shallow foundations.
- IS: 8009 Code of Practice for foundation settlement calculations.
- IS: 13301 Guidelines for vibration isolation for machine foundations



**9.3.1.3 Concrete Structures**

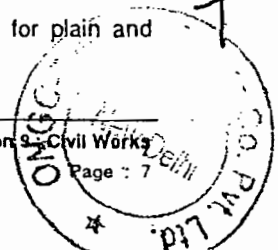
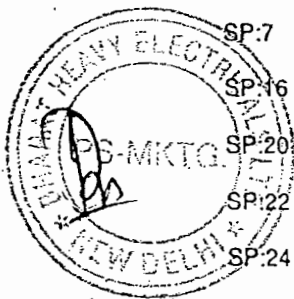
- IS: 456 Code of practice for plain and Reinforced concrete.
- IS: 3370 Code of practice for concrete structures for the storage of liquids.
- IS: 3414 Code of Practice for design and installation of joints in buildings
- IS: 4326 Code of Practice for earthquake resistant design and construction of buildings
- IS: 5525 Recommendation for detailing of reinforced concrete works
- IS: 6313 Code of practice for anti-termite measures in buildings
- IS: 13920 Ductile detailing of Reinforced Concrete Structures subjected to Seismic forces.

**9.3.1.4 Steel Structures**

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

**9.3.1.5 Miscellaneous**

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



SP:25	Handbook on causes and prevention of cracks in buildings
SP:32	Handbook on functional requirements of industrial buildings
SP:34	Handbook of concrete reinforcement & detailing (SCIP)
IRC:37	Guidelines for design of flexible pavements
IRC:58	Guidelines for the design of rigid pavements for highways
IRC:73	Geometric design of roads

### 9.3.2 Design Criteria – Architectural and Finishing Works

#### 9.3.2.1 Architectural Design

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

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

#### Space Requirement

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

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

#### Layout

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

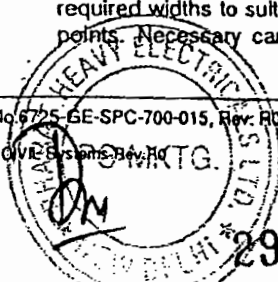
#### Design Consideration

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

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

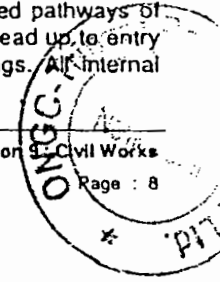
#### Circulation

All buildings and open plant areas must be approachable by roads / paved pathways of required widths to suit the openings / approach to the buildings and shall lead up to entry points. Necessary car parking space shall be provided near the buildings. All internal



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corridors / passage inside the building shall have a clear width of minimum 1800 mm unless otherwise specified. All fire fighting equipment etc. shall be provided in suitable niche as per requirements.

#### Ventilation

Provision for natural ventilation and lighting as also for mechanical ventilation, pressurization, air conditioning shall be provided taking into consideration the local conditions, the activity and equipment in the building, statutory requirements and specific requirement, if any. Generally openable windows of area not less than 15% of the floor area shall be provided for natural ventilation. All outside doors, windows shall be adequately protected by sunshade (min.750 mm projection sunshades shall be provided with drip mould). The area of ventilation shall not be less than as specified / statutory requirement. Exhaust fan shall be provided in Toilet & battery room areas. 50 mm thick R.C.C. jali / ventilators / louvers shall be provided in cellar areas for ventilation.

#### Acoustic Treatment

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

### 9.3.2.2 Architectural Requirements

#### Toilets

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

Toilets shall be provided with all necessary approved Indian Standard fittings. The floor of toilet shall have a drop of 15 mm from general floor level and shall have sufficient slope towards drain trap. Sufficient natural light and ventilation shall be provided as per requirement. Unless specified each toilet shall be provided with minimum one W.C. (water closet), one urinal, one washbasin, towel rail, mirror and liquid soap container, glass shelves etc. Western/Indian style water closets shall be provided as specified / directed by the Owner's Engineer.

#### Ramps

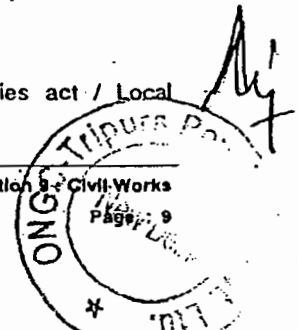
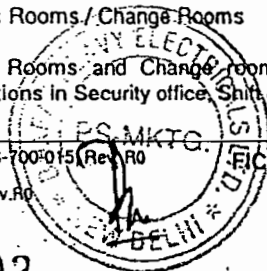
Ramps shall be provided for equipment entry. Slope shall not be steeper than 1:7, unless otherwise specified.

#### Stairways

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

#### Lockers Rooms / Change Rooms

Locker Rooms and Change rooms shall be provided as per Factories act / Local Regulations in Security office, Shift offices etc.



**Layouts of plant buildings**

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

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

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

Generally the building floors shall be 450 mm above the finished ground level of the respective areas.

**Masonry walls**

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

**9.3.2.3 Architectural and Finish Specification**

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

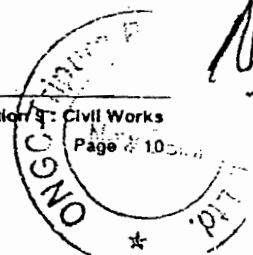
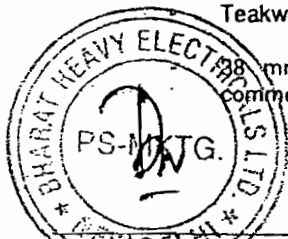
Minimum size of single shutter door shall be 1200 mm x 2100 mm. For higher widths double shutters shall be provided. Maximum size of double shutter doors shall be restricted to 2000 mm x 2500 mm beyond which Rolling shutters shall be used.

**a. Doors, Windows, Ventilators, Louvers and Rolling Shutters****Steel Door**

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

**Timber Door****Teakwood frames.**

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



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

#### Aluminum doors, partitions & windows

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

#### Steel Windows / Ventilators

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

#### Steel Louvers

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

#### Rolling shutter

- Shutter made from 18 gauge steel sheets. Guides 75 mm x 25 mm steel channel.
- Details as per IS:6248.

#### b. Floor finishes

##### Indian Patent Stone (IPS) flooring

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

##### Cast-in-situ terrazzo flooring

- 25 mm thick under bed in PCC 1:1.5:3 with 10 mm downgraded granite stone chips.
- 15 mm thick terrazzo topping with 6 mm down marble chips of approved color.

- Panel size 1000 mm x 1000 mm with 40 mm x 3 mm thick glass dividing strip.

**Precast Terrazzo tiles**

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

**Carborundum tiles**

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

**Acid Resistant Tiles**

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

**Glazed Tiles**

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

**Ceramic Floor Tiles**

- 15 mm underbed in cement mortar 1:3
- Ceramic floor tiles (SPARTEK or approved equivalent).

**PVC Tiles**

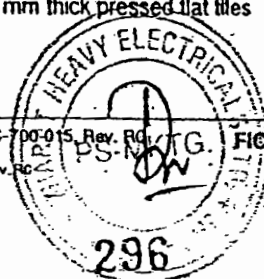
- 37 mm thick underbed in PCC 1:2:4 in areas without false flooring.
- To be directly installed over particle board tiles in false floor areas.
- 2 mm thick PVC tiles over false flooring and 3.02mm in other areas conforming to IS:3461/IS:3462.

**Epoxy coating**

- Details as per detailed specification covered in Section B8.5.

**c. Roof finishes****Roof waterproofing with pressed flat tiles**

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



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**Roof waterproofing with polymeric membrane**

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

**Basement damp proofing with polymeric membrane**

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

**d. Painting****Oil bound distemper**

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

**Synthetic enamel**

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

**Acrylic Plastic Emulsion**

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

**Waterproof Cement Paint**

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

**White washing / color washing**

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

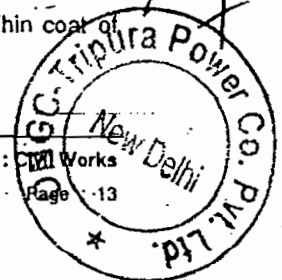
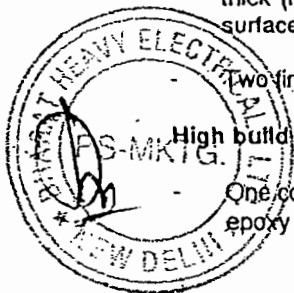
**Chlorinated Rubber Paint**

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

Two final coats of chlorinated rubber paint each 40 microns thick.

**High build Epoxy paint**

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



- Two finish coats of epoxy high build paint.

**High build Coal Tar Epoxy Paint**

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

**Chemical Resistant Phenolic based enamel**

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

**Acrylic Polyurethane Paint**

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

**e. Underdeck Insulation**

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

**f. False Ceiling**

LUXALON 84C or equivalent suspended by galvanised stud wire hangers.

Particle board tiles 6 mm thick supported by Aluminium Tee runners.

**g. False Flooring**

35 mm thick particle board tiles 610 mm x 610 mm supported on steel grid and with 2 mm thick PVC tile topping.

Base Plate thickness	-	10mm
Channel Thickness	-	2.5mm
Support Stud diameter	-	20mm

**h. Sheetting****Permanent colour coated sandwiched insulated metal cladding system**

Troughed zinc - aluminium alloy coated (both sides) MS sheet having 0.6 mm minimum thickness (or high tensile steel sheet of 0.5 mm minimum thickness) shall be used on external face (outer face) of cladding system. Weight of coating shall not be less than 150 gm /sq.m. The outer side (exposed face) shall be permanently colour coated with Polyurethane Vinyl Coating (PVF2) of Dry Film Thickness (DFT) 20 microns (min) over primer. Inner side of external sheet shall be provided with suitable pre-coating of minimum 20 microns.

Galvanized MS sheets of minimum 0.6 mm thickness shall be used as inner-leaf (internal face) of cladding system. The exposed face shall be permanently colour coated with

silicon modified polyester paint of DFT 20 microns (min) over primer. Inner face of external sheet shall be provided with suitable pre-coating of minimum 7 microns. The rate of galvanization shall not be less than 150 gm /sq .m.

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

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

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

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

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

#### Flashings, caps, trim closures etc.

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

### 9.3.3 Design Criteria - Plumbing and Sanitary Works

#### a. Water Supply

##### Materials

- Water supply pipes shall be GI. pipes conforming to IS:1239 (Part I), medium grade and GI. fittings shall conform to IS:1239 (Part II).
- Isolation valve (up to 50 mm) shall be of gun metal conforming to IS:778 (Class II).

Valve pits for gunmetal valve shall be in brick construction.

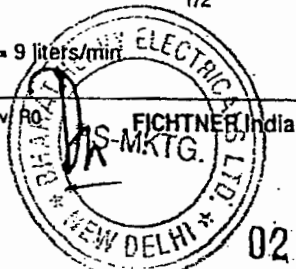
##### System

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

#### Fixture unit value for peak discharge

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

Fixture unit value = 9 liters/min



Before entering the building, an isolation valve shall be provided on water supply line.

#### Flushing Tanks

- Provision of flushing tanks for each toilet shall be made having following storage capacities.

Fixture	Storage Capacity (Litres)
Per WC	15
Per Urinal	5

#### b. Sanitary Fixtures

Sanitary fittings shall be of approved brand of the following sizes and specification.

Indian Water Closet(IWC)	- Orissa pan of size 580 mm conforming to IS:2556.
European Water Closet (EWC)	- Conforming to IS:2556 with plastic seats and low level PVC Cistern of 15 litres capacity.
Urinals	- Flat back half shell of size 610 mm x 410 mm x 380 mm including a pair of 250 mm x 125 mm white ceramic foot rest.
Wash basin	- 550 mm x 400 mm conforming to IS:2556 with chromium plated bottle trap.
Mirror	- 600 mm x 450 mm x 6 mm bevelled edge mirror
Glass shelve	- 600 mm x 127 mm x 4 mm with chromium plated brackets.
Towel Rail	- 12 mm dia x 457 mm long, chromium plated.

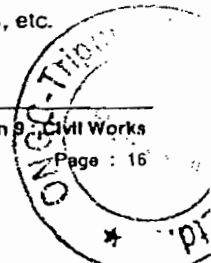
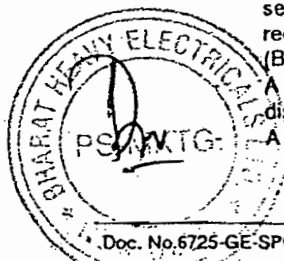
#### c. Sewerage

##### Materials

- All horizontal buried soil and waste pipes shall be of stoneware or PVC, socket and spigot and shall conform to relevant IS.
- All vertical soil, waste and vent pipes shall be of PVC conforming to relevant IS.
- Manholes and gully trap chambers shall be in brick construction.

##### System

- The system shall be designed on the principle of "TWO PIPE SYSTEM" having two separate vertical pipes namely Main Soil Pipe (MSP) and Main waste Pipe (MWP) receiving waste from number of Branch Soil Pipes (BSP) and Branch Waste Pipes (BWP)
  - A BSP either shall have only one WC. to be connected to MSP or it shall receive discharge from number of urinals to be connected to MSP.
  - A BWP shall receive waste from wash basins, baths, sinks, cooler areas, etc.



- Floor traps shall be provided to receive waste from waste pipes of various fixtures (except from WC, which shall be directly connected to MSP) and at locations where waste water is to be drained out.
- A MSP shall be directly connected to first manhole of an outside sewer.
- A MWP shall be discharged into first manhole through a gully trap.
- All vertical stacks and ventilating pipes shall be carried to a height of at least 1.5 meters above parapet and shall be provided with cowl on top.
- Gradient of the sewage piping shall be at least 1:200.

#### Sizing

The soil and waste pipe diameters shall be based on fixture units as given below:

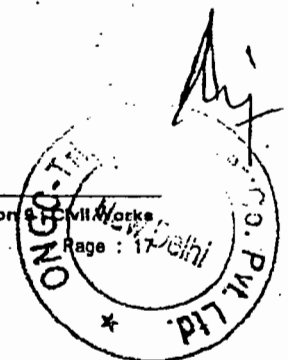
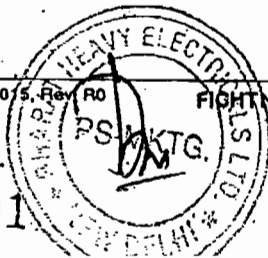
#### Fixture Units for Different Sanitary Appliances

Type of Fixture	Fixture Unit Value as Load Factor
Water closet, tank-operated	4
Water closet, valve-operated	8
Urinal	4
Showers (group) per head	3
Wash basin ordinary	1
Kitchen sink, domestic	2
Floor trap	1
Drinking fountain	1/2

#### Recommended Pipe Sizes for Branches and Main Vertical Pipes (STACKS)

Diameter of pipe (mm)	Max. Number of Fixture Units that may be connected to	
	Any Horizontal fixture branch	One stack of 3 stories in Height or 3 intervals
1	2	3
30	1	2
40	3	4
50	6	10
65	12	20
80	20	30
100	160	240
150	620	960

- Minimum size of BSP receiving discharge from WC, shall be 100 mm up to MSP/first manhole.
- Minimum size of BWP shall be 80 mm.
- Minimum size after gully trap up to first manhole shall be 100 mm.



**Gradients**

- The gradient of a horizontal branch shall be such that non-silting & non-scouring velocity is maintained.

**Disposal**

- Treated sewage can be used for horticulture. Treated solid wastes can be used as manure.

**9.3.4 Design Criteria – Loads & Load Combinations**

All structures shall be designed for the most critical combinations of dead loads, imposed loads, equipment loads, crane loads, steam piping (static & dynamic) and other piping loads, wind loads, seismic loads and any other loading conditions which can occur during the design life of the facility.

Design loads shall comply with the requirements of IS 875 & IS: 1893 as a minimum, unless more stringent requirements are specified herein. The following types of loads shall be considered in general for the analysis and design of structures and foundations.

**9.3.4.1 Dead Loads (DL)**

Dead loads consist of the weights of the structure complete with finishes, fixtures, partitions, wall panels and all equipment of semi-permanent nature including tanks, partitions, roofing, piping, cable trays, bus ducts etc.

Self-weight of materials may be calculated on the basis of unit weights given in IS:875 (Part 1). The following unit weight of material shall be considered for computation of loads

<u>Materials</u>	<u>Unit Weight</u>
Plain Cement Concrete	24 kN/m <sup>3</sup>
Reinforced Cement Concrete	25 kN/m <sup>3</sup>
Structural Steel	78.5 kN/m <sup>3</sup>
Brick work	19 kN/m <sup>3</sup>
Cement Plaster	21 kN/m <sup>3</sup>
Floor finish	24 kN/m <sup>3</sup>

**9.3.4.2 Equipment loads (EQL)**

Equipment causing heavy concentrated loads shall be considered separately. Loading data shall be initially estimated from suppliers' catalogues or from similar equipment supplied for other projects and the same shall be later verified based on certified manufacturer's drawing. Where both concentrated and uniform loads cannot act simultaneously, the structure shall be checked for each condition of loading separately and shall be designed for the more critical condition. The loading considered for tanks and piping shall include hydraulic test load. Crane girders and supporting columns shall be designed for vertical and lateral loads as furnished by the manufacturer. In the absence of data from manufacturer, wheel loads are estimated from crane weights and capacity of the crane and lateral loads and impact factors are arrived at based on the recommendations furnished in IS:875. Laydown areas in the turbine and generator halls shall be designed for concentrated loads resulting from storage of equipment components during erection and maintenance, and such areas shall be identified by permanent marking.

Static and dynamic loads of major equipments shall be based on the manufacturer's data of the specified equipments. However, where the uniform floor live load adequately

accounts for the equipment moving weight, the weight of such equipment as a dead load shall not be considered e.g. switchgear and control room floors are usually designed for a live load that includes the equipment weight.

While arriving at seismic forces, the equipment loads should be accounted as dead loads.

All equipments, tank and piping design loading shall include hydraulic testing loads. Weight of equipments, ducts, tanks, pipes, conduits etc. supported by structure shall include maximum possible loading conditions i.e. flooded material contents and associated impacts, test loading, anchorage and constraint effects.

Air duct loads shall include weight of insulation, duct attachments, dust accumulation loads, seismic or wind whichever is applicable and other loads as applicable.

#### 9.3.4.3 Imposed Loads (IL)

##### General

Imposed loads noted below are the general equivalent uniformly distributed loads to account for equipment/piping/cable tray/erection loads etc. and personnel movement. Where the actual loads of the equipment exceeds in specific areas due to concentration of facilities, the same shall be substituted in lieu of the above loads, in which case a nominal live load of 5 kN/m<sup>2</sup> shall be considered in the adjacent areas not covered by the equipment.

Imposed loads in different areas shall include live loads, minor equipment loads, cable trays, small pipe racks/ hangers, erection loads, operation / maintenance loads etc. The loads considered shall not be less than that specified in IS : 875 (Part II).

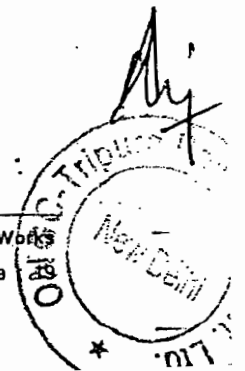
The loads listed hereunder are minimum live loads for the areas involved. Special use areas shall be investigated and loads revised upward as necessary. Floors and supporting members which may be subjected to heavy equipment live loads shall be designed on the basis of the weight of equipment or specifically defined live loads, whichever is greater.

##### Roofs

- |                |   |   |
|----------------|---|---|
| a. Flat Roof   | : | 1.5 kN/m <sup>2</sup> for accessible roofs      |
|                | : | 0.75 kN/m <sup>2</sup> for non-accessible roofs |
| b. Sloped Roof | : | As per IS : 875                                 |

##### STG, GTG, Switchgear and Control Buildings

Ground floor		
- General	:	15 kN/m <sup>2</sup>
- Unloading bay	:	Actual
Mezzanine floor	:	10 kN/m <sup>2</sup>
Cable spreader rooms	:	5 kN/m <sup>2</sup>
Operating floor		
- General	:	15 kN/m <sup>2</sup>
- laydown area	:	25 kN/m <sup>2</sup>
Switchgear floor	:	15 kN/m <sup>2</sup>
Control room	:	10 kN/m <sup>2</sup>



Battery Rooms	: 10 kN/m <sup>2</sup>
AHU, AC & Ventilation plant floors	: 10 kN/m <sup>2</sup>
PLCC, relay room	: 10 kN/m <sup>2</sup>
Platform & Stairs	: 5 kN/m <sup>2</sup>
Other floors	: 10 kN/m <sup>2</sup>
Chequered Plate & Grating floors (including opening covers)	: 5 kN/m <sup>2</sup>
<b>Other Plant Buildings and Areas</b>	
Ground floor/Operating floor	: 10 kN/m <sup>2</sup>
Switchgear floor	: 15 kN/m <sup>2</sup>
Stores	: 15 kN/m <sup>2</sup>
Control Room	: 10 kN/m <sup>2</sup>
Stairs and balconies	: 5 kN/sqm

The above loads are applicable for slabs & secondary beams. 75% of the above load may be considered for design of columns & foundations as it is unlikely that the entire tributary area of the slab will be fully loaded at all levels at the same time.

However, for design of slabs and beams, in addition to the above loads, a live load of 2.5 kN/m<sup>2</sup> and concentrated load of 10 kN at the worst location shall be considered in Operating floor, Switchgear room & Control room to cater for hung loads due to piping and cable trays. Loads due to critical piping shall be taken at actuals and checked for local effects.

A minimum UDL of 1.0 kN/sqm shall be considered as Hung loads for ventilation & air conditioning and miscellaneous piping in other floors as applicable.

For areas not covered above and for Non-plant buildings, the relevant loadings furnished in IS:875 (Part 2) shall govern.

#### Piping Anchor and Restraint Loads

Piping load shall be as per load plan drawings unless otherwise mentioned.

Piping anchor and restraint forces of major piping shall be obtained from piping analysis results, and be considered as live load in the structure design.

#### Miscellaneous

Culverts and allied structures including buried RCC Pipes shall be designed for IRC Class "AA" loading and checked for Class 'A' loading.

Covers for trenches & tunnels that are not exposed to vehicular traffic shall be designed for Live Load of adjoining areas or 5 kN/m<sup>2</sup> whichever is higher. Where trenches / tunnels channels are likely to be exposed to vehicular traffic, the requirements of Code of Practice for Road Bridges shall be adhered to.

For design of walls of basement, trenches, channels etc. below ground, lateral pressure due to a vertical surcharge of 15 kN/m<sup>2</sup> shall be considered in addition to earth and ground water pressure etc. In case of heavy wheel loads, lateral surcharge due to actual wheel loads shall be substituted. When a portion or whole of the adjacent soil is below free water surface, computations shall be based on submerged weight of soil plus full hydrostatic pressure.

Live Loads reduction shall be in accordance with the provisions of IS : 875 & IS : 1893.

#### 9.3.4.4 Crane Loads (CRL)

Crane girders and supporting columns shall be designed for vertical and horizontal forces (including impact forces) as per crane vendor's data. All lifting beams and monorails shall have their design loads increased for impact factor as mentioned hereinafter.

Loads including impact factor for cranes, hoists and elevators shall be taken as per IS:875 (Part 2).

#### 9.3.4.5 Wind loads (WL)

Wind load shall be in accordance with IS:875 (Part-3). The wind shall be assumed to blow in any direction and most unfavorable condition shall be considered.

Basic Wind Speed	-	55 m/s
Risk Coefficient (k1 factor)	-	1.08 (for plant structures)
	-	1.0 (for non-plant buildings)
Terrain Category for k2 factor	-	Category 2
Topography (k3) factor	-	1.0

The external / internal pressure co-efficients shall be as per respective clauses of IS 875 (Part-3)

In design of structures, wind force on equipments supported on frame including all fixtures, piping, staircases, ladders, handrails etc. shall also be considered.

#### 9.3.4.6 Seismic load (SL)

Seismic loads shall be in accordance with IS:1893-2002, corresponding to Zone - V. The following factors as per the code shall be considered to arrive at the seismic loads.

Zone factor (Z)	-	0.36
Importance factor (I)	-	1.5 for power plant buildings
	-	1.0 for other non- plant buildings
Response Reduction Factor (R)	-	3 for RCC Structures
	-	4 for Steel structures (for both moment connected and braced frames)

Shear enhancement as per Clause 7.8.2 of IS: 1893-2002 shall be considered. Seismic analysis shall be carried out by Response Spectrum method for critical structures like STG building, GTG Building, CW Pump House etc. and structures more than one storey high. Single storey buildings / structures may be analysed by equivalent static load method.

Seismic loads for structures not covered in IS : 1893-2002, shall be evaluated based on 1984 version of the code.

Dynamic increment of water pressure and earth pressure due to Seismic Loads shall be evaluated using IS : 1893: 1984 or other relevant Indian / International codes.

**9.3.4.7 Earth Pressure**

Earth pressure for design of underground structures shall be based on co-efficient of active earth pressure and earth pressure at rest for cantilever and propped cantilever / two way supported walls respectively.

**9.3.4.8 Load Combinations**

The individual members of the structures shall be designed for worst combination of forces such as bending moment, axial force, shear force and torsion.

Wind load and Earthquake load shall be assumed not to act simultaneously. The effect of both the forces shall be considered separately in each direction (along and across).

**Building / Structures**

The following are the general load combinations to be considered for analysis of buildings / structures.

DL + EQL  
DL + IL + EQL  
DL + IL + EQL + CRL1  
DL + WL1  
DL + WL2

DL + IL + EQL + CRL1 + WL1  
DL + IL + EQL + CRL1 + WL2  
DL + 0.5 IL + EQL + CRL2 + SL1  
DL + 0.5 IL + EQL + CRL2 + SL2

**Where**

DL = Dead Load  
IL = Imposed Load  
EQL = Equipment Load  
CRL1 = Crane Load with lifted weight and surge load (including impact)  
CRL2 = Crane Load without lifted weight.  
WL1 = Wind Load from left to right  
WL2 = Wind Load from right to left  
SL1 = Seismic Load from left to right  
SL2 = Seismic Load from right to left

**Note**

1. If equipment load is taken at actuals, live load of 5 kN/m<sup>2</sup> only shall be considered.
2. Equipment loads, shall not be considered as a part of DL for checking the stability of the structure.
3. 0.9 times DL shall be considered for checking stability.
4. Wind load and Seismic load shall be assumed not to act simultaneously. The effect of both the forces shall be considered separately in each direction (transverse and longitudinal).

For buildings with GI sheet metal on structural steel truss & open sides

DL + IL  
DL + WL1  
DL + WL2

**Underground Structures**

Following loading conditions shall be considered in addition to the loading from super structure for the design of substructure of pump house, channels, sumps, tanks, reservoirs, trenches and other underground structures.

- a. Only liquid pressure from inside and no earth pressure & ground water pressure and surcharge pressure from outside (applicable only to structures which are liable to be filled up with water or any other liquid).
- b. Earth pressure, surcharge pressure and ground water pressure from outside and no water or liquid pressure from inside.
- c. Base slab of the sump shall be designed for the condition of different combinations of pump sumps being empty during maintenance stages with maximum ground water table. Intermediate dividing piers of pump sumps and partition walls in channel be designed considering water on one side only and the other side being empty for maintenance.

**Note :**

- a. Liquid pressure and surcharge load shall include Seismic effects also as applicable.
- b. The underground structures shall be checked for buoyancy due to ground water pressure during construction phase (without superstructure loads).

**9.3.4.9 Loading Criteria for Pipe and Cable Rack Structures****a. Design Loads**

Loads due to self-weight of piping, insulation, valves etc. and the self-weight of structures constitute the Dead Loads. In the absence of exact loading, general uniformly distributed loading as indicated below shall be considered depending on the pipe size and spacing.

Category	Udl	Equivalent Pipe Size
Light	1.5 kN/m <sup>2</sup>	150 mm dia, schedule 40 @ 250 C/C
Medium	2.0 kN/m <sup>2</sup>	200 mm dia, schedule 30 @ 300 C/C
Heavy	3.0 kN/m <sup>2</sup>	250 mm dia, schedule 20 @ 300 C/C

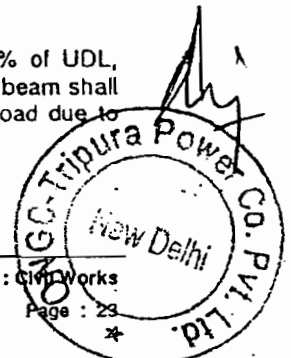
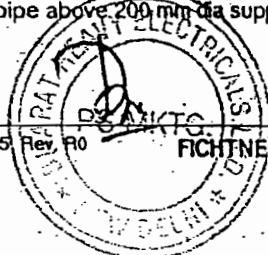
In case larger size pipes are supported, additional point loads shall be considered in addition to the above loads.

Cable-tray loads shall be taken as 100 Kg/m per layer for 600 mm wide tray and proportionately for other sizes. Cable tray supports shall be generally provided at 1.5 m c/c.

The above loads shall be compared with actual piping and cable tray loads and highest loads shall be considered for final design.

The main beams shall be designed to cater for 100% of UDL indicated above, unless intermediate beams are provided, in which case, the load on the main beam can be reduced by 20%.

The intermediate beams and longitudinal beams shall be designed for 25% of UDL, provided pipes are supported only on main beams. In addition the longitudinal beam shall be designed for the reaction from the intermediate beam and concentrated load due to branch / loop pipe above 200 mm dia supported on them.



Unless otherwise specified, friction/temperature loads, shall be taken as 15% of the vertical load and assumed to act on the main beams as UDL, in a direction parallel to the pipes, and perpendicular to the pipes as concentrated load applied at the beam level. Both transverse and longitudinal friction shall be considered together.

Anchor forces shall be as per piping layout and pipe stress analysis. All anchors shall be located on the main transverse beams only.

Wind force acting on the rack frames shall be estimated based on the wind pressure arrived at from the design wind speed and force coefficients for windward frame and shielded frame respectively.

#### b. Load Combinations

The following load combinations shall be considered for Pipe Racks

DL ± FL ± AL  
DL ± FL ± AL ± WL  
DL ± WL

Where,  
DL = Dead Load  
FL = Friction Load  
AL = Anchor Load

In case Seismic Load (SL) is governing, WL shall be substituted with SL in the above combinations.

#### 9.3.4.10 Increase in Allowable Stresses

Appropriate increase in allowable stresses as per applicable IS Codes shall be considered under wind / seismic loading if design is carried out by Elastic/Working Stress method. If Limit State method of design is used, partial safety factors/load factors shall be applied to the loads as per relevant IS Codes.

#### 9.3.5 Design Criteria - Reinforced Concrete Structures and Foundations

##### 9.3.5.1 General

All structures, building foundations, machines / equipment foundations, water retaining structures, trenches, pits etc. shall be designed as per relevant IS Codes in general.

All designs of RCC structures shall be carried out by limit state method as per IS:456 unless use of working stress method is specifically mentioned. Design strength of materials and design loads shall be calculated using appropriate partial safety factors over characteristic strength and characteristic loads as per IS:456. For reinforcement detailing IS:5525 and SP:34 shall be followed.

The walls of liquid retaining structures shall be provided with reinforcement on both faces for sections 200 mm or more, even if not required from design consideration.

##### 9.3.5.2 Increase in Stresses

Where stresses due to wind (or seismic) are combined with those due to other loads, the allowable stresses in concrete and reinforcement steel may be increased by 33.33% in case of working stress design.

Where the bearing pressure on soil due to wind load alone is less than 25% of that due to dead load and imposed load, it may be neglected in design. Where this exceeds 25%, foundation may be so proportioned that the pressure due to combine effect of dead load, imposed load and wind load does not exceed the allowable bearing pressure by more than 25%. When seismic loads are included, the permissible increase in allowable bearing pressure shall be as per IS:1893.

Appropriate increase in allowable stresses as per applicable IS Codes shall be considered under wind / seismic loading if design is carried out by Elastic/Working Stress method. If Limit State method of design is used, partial safety factors/load factors shall be applied to the loads as per relevant IS Codes. The above references are only guide lines and not limiting criteria.

### 9.3.5.3 Foundation

#### a. General.

The foundation type and depth shall be decided based on the final soil investigation to be carried out by the EPC Contractor and recommendations based on the same. Minimum depth of foundation shall be 750mm below the natural ground level.

Settlement criteria for shallow foundations shall be generally as follows, or more stringent as per specific equipment requirement & differential settlement criteria.

- 25 mm for plant buildings and structures.
- 40 mm for non-plant buildings and structures.
- 150 mm for steel storage tank foundations (floating roof)
- 200 mm for steel storage tank foundations (fixed roof)

Settlement criteria for pile foundation shall be as per IS:2911.

75 mm thick lean concrete 1:4:8 shall be provided below footings, base slab etc. as mudmat. For water retaining structures mud mat shall be of mix. 1:3:6 and minimum 100 mm in thickness.

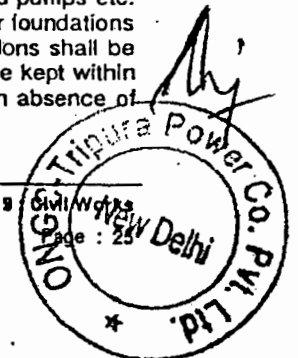
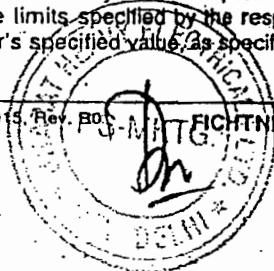
The Factors of safety for stability of foundation and underground structures shall be as per IS: 456 & IS: 3370.

Additional depth of excavation shall be filled up with PCC 1:5:10.

Piles shall be checked for vertical and lateral loads. Vertical load capacity shall be calculated based on soil bearing capacity (as per IS:2911) and structural capacity. Lateral capacity shall be evaluated based on horizontal sub-grade reaction approach as per IS : 2911. Structural design of pile shall consider the worst loading (minimum vertical load and maximum moment due to design lateral loads or maximum vertical load capacity combined with maximum moment capacity). Structural load capacity of piles shall be evaluated based on limit state method. The structural capacity shall be calculated for working as well as test piles (load factor for test pile shall be equal to the ratio of test load to design load).

#### b. Foundations for Vibrating Machinery

Design of foundations for vibratory Equipment such as GTG, STG, Boiler feed pumps etc. shall be done in accordance with IS:2974 and they shall be isolated from other foundations for vibration control. To avoid resonance, natural frequencies of the foundations shall be kept at least 20% away from the operating frequency and amplitudes shall be kept within the allowable limits specified by the respective equipment manufacturer or in absence of manufacturer's specified value, as specified in the IS Codes/DIN Codes.



The design of machine / equipment foundation shall be as per IS : 456 and IS : 2974.

All block foundations resting on soil shall be analysed considering dynamic properties of soil. The mass of the RCC block shall not be less than the three times the mass of the machine. Dynamic analysis shall be carried out to calculate natural frequencies in all the modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant codes and / or machine manufacturers shall be satisfied. Minimum reinforcement shall be governed by IS:2974 and IS : 456.

For the foundations supporting minor equipments weighing less than one ton or if the mass of the rotating parts is less than one-hundredth of the mass of the foundation, no dynamic analysis is necessary. However, if such minor equipment is to be supported on building structures, floors etc. suitable vibration isolation shall be provided by means of springs, neoprene pads etc. and such vibration isolation system shall be designed suitably.

All such foundations shall be separated from adjoining part of building and other foundations. Joints at floor / slab shall be suitably sealed. All appendages to such foundations shall be reinforced suitably to ensure integral action.

#### c. Foundation for Chimney

The stability of the foundation as a whole shall be investigated and weight of foundation shall be so proportioned that the least resisting moment shall be not less than 1.5 times the maximum overturning moment due to dead load and wind load / seismic load in shell alone case and 2.0 for the completed chimney. Foundation shall be in the form of rigid mat.

No increase in bearing capacity or in stress shall be allowed for wind loads.

#### 9.3.5.4 Concrete

For structural concrete items, Ordinary Portland cement (43 Grade) conforming to IS:8112 shall be used for superstructure. Type of cement for substructures shall be decided based on the final Soil Investigation Report.

All structural concrete shall be made dense and nonporous with water cement ratio not exceeding 0.45. Plasticizers shall be used, if required, to maintain the required slump.

The following grades of concrete as per IS:456 shall be adopted for the type of structures noted against each.

M20 - Lightly loaded structures, Grade slab, paving, drain, pipe trenches, cable trenches, culverts, roads, etc.

M25 - All structural elements above and below ground level

M30 - For GTG, STG, Chimney foundations and water retaining structures

M30 - Precast concrete

1:3:6

Mudmat below tank foundations

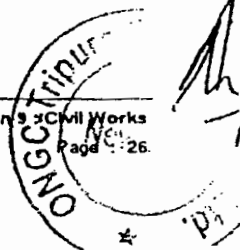
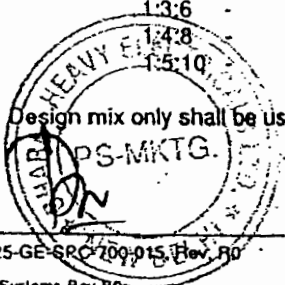
1:4:8

Plain Concrete Footing, base slab of drains.

1:5:10

Fill concrete.

Design mix only shall be used for construction.



Minimum cement content for different grades of concrete shall be as follows, unless more stringent requirements are specified in the relevant codes.

M20	-	360 kg/m <sup>3</sup>
M25	-	400 kg/m <sup>3</sup>
1:3:6	-	216 kg/m <sup>3</sup>
1:4:8	-	165 kg/m <sup>3</sup>
1:5:10	-	130 kg/m <sup>3</sup>

#### 9.3.5.5 Reinforcements

High yield strength deformed bars conforming to IS 1786 shall be used for reinforcement.

#### 9.3.5.6 Minimum Thickness of Structural Elements

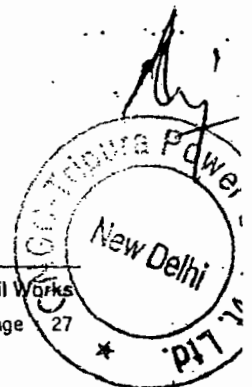
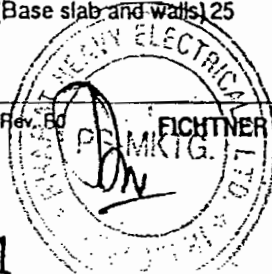
The following minimum thickness shall be followed :

a. Suspended floor slab / roof slab / walkways / canopy slabs, etc.	-	100 mm
b. Ground floor slab (non - suspended)	-	150 mm
c. Water Retaining Slab / Walls	-	150 mm
d. Cable / Pipe Trenches / Underground pit / Launder walls and base slab	-	100 mm
e. All footings (including raft foundations)	-	250 mm
f. Tapered footings	-	150 mm (Min. at edges)
g. Parapets / Chajjas	-	75 mm
h. Precast louvers / fins	-	50 mm
i. Precast trench cover slabs / floor slabs louvers	-	75 mm
j. Precast beams	-	150 mm
k. Paving	-	150 mm
l. Basement walls and base slab	-	150 mm

#### 9.3.5.7 Minimum Cover to Reinforcement

Clear cover to reinforcement shall be as follows:

	Top (mm)	Bottom (mm)	Sides (mm)
Footings (Raft and Isolated)	50	75	50
Grade beam	40	40	40
Grade slab	25	25	25
Columns & Pedestals	50	-	50
Beams above ground level	35	35	35
Lintel beams (Size < 300 x 300)	25	25	25
Block foundation including			
GTG/STG foundation	50	100	50
Slabs & staircases	25	25	25
Cable trenches			
Base slab	20	35	35
Roof slab	15	35	35
Walls	20	35	35
Liquid retaining Structures			
Base raft	40	40	40
Side Walls (Water face)	30	-	30
Side Walls (Soil face)	50	-	50
Precast Units	15	25	20
Surface Drains (Base slab and walls)	25	25	25



**9.3.5.8 Minimum Cover for Foundation Bolts, Base Plates and Pockets**

- a. Clear distance from the edge of the base plate / base frame to the outer edge of the pedestal shall be minimum 50 mm.
- b. Clear distance from the face of pocket to the outer edge of the pedestal / foundation shall be 75 mm.
- c. Clear distance from the edge of the sleeve or anchor plate to the edge of pedestal shall be 75 mm.

**9.3.5.9 Minimum Heights for Pedestals of Steel Columns****Pedestals to Steel columns for building structures**

Top of RCC foundations (pedestals) shall normally be kept at a height of 300 mm above the floor level.

**Other Pedestals and Foundations**

- |                                     |   |
|-------------------------------------|---|
| i. Stair and ladder pedestal        | - 200 mm above the finished floor level                                 |
| ii. Equipment in open area          | - as required (300 mm min.)   |
| iii. Equipment in covered area      | - as required (150 mm min.)   |
| iv. Structures / equipment supplied | - as per vendor's data subject to by vendors minimum as specified above |

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

- |                  |  |
|------------------|--|
| i. Open area     | - 300 mm above FPL/FGL, whichever is higher. |
| ii. Covered area | - 150 mm above the finish floor level        |

FPL = Finished Paved Level  
FGL = Finished Grade Level

**9.3.5.10 Grouting**

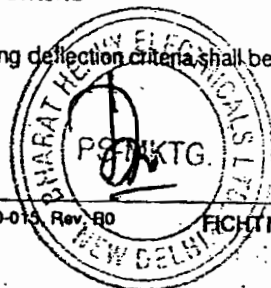
Cement mortar (1:1 or 1:2) grout with non-shrink additive shall be used for grouting below base plate of columns. For grouting of base of machine foundation, high strength ready mixed non shrink grout of approved brand (approved by OEM and Owner's Engineer) shall be used.

Crushing strength of the grout shall generally be one grade higher than the base concrete. Minimum grade of grout shall be M30.

Nominal thickness of grouting shall be atleast 50 mm for building columns and pedestals of major equipments. For secondary posts, stair and ladder base etc. grouting shall not be less than 25 mm thick.

**9.3.5.11 Deflection Criteria**

The following deflection criteria shall be considered in sizing of structures as per IS:456.



- i. The final deflection due to all loads including effects of temperature, creep, and shrinkage, measured from as cast level of the supports of floors, roofs & all other horizontal members shall not exceed  $spar/250$ .
- ii. The deflection including effects of temperature, creep & shrinkage occurring after erection of partitions and the application of finishes shall not exceed  $spar/350$  or 20mm whichever is less.

Under transient wind load the lateral sway at the top should not exceed  $H/500$ , where H is the total height of the building.

The maximum horizontal relative displacement due to seismic forces between two successive floors shall not exceed 0.004 times the difference in level between these floors.

#### 9.3.5.12 Ductile detailing

Ductile detailing in accordance with IS : 13920 shall be adopted for superstructure and substructure of all RCC buildings / structures.

#### 9.3.5.13 Water Retaining Structures / Basements

Water Retaining structures shall be designed as uncracked sections by working stress method as per IS : 3370.

Dry basements for which external water proofing is not provided and subjected to ground water pressure from outside may be designed in accordance with the recommendations of IS:456. Crack width shall be restricted to 0.1 mm.

Minimum thickness of structural elements for water retaining structure with two layers of reinforcement shall be 200 mm.

#### 9.3.6 Design Criteria - Steel Structures

##### 9.3.6.1 Framing

All steel framed structures shall generally be of rigid frame in the generally transverse direction and braced frame in the longitudinal direction with bracing confined to selected bays.

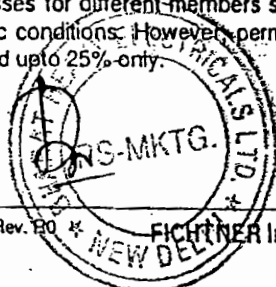
Lateral forces shall be resisted by stiff jointed moment connections in rigid frame design. The column bases shall generally be fixed to concrete pedestal / column by providing moment resistant base detail.

##### 9.3.6.2 Design Methodology

The design of steel structures shall be done by working stress method in accordance with the provisions of IS : 800 and other relevant IS codes as applicable to specific structures.

Crane gantry girders shall be a rolled section with flange plate and or welded construction with bearing and intermediate stiffeners. Crane girder shall be designed as simply supported and of single span length.

Permissible stresses for different members shall be allowed to exceed by 33-1/3% under wind and seismic conditions. However, permissible stresses in bolts and welds shall be allowed to exceed upto 25% only.



For design which requires the use of the minimum column load (such as, uplift on anchor bolts, column axial tension etc.) 90% of Dead Load along with uplift forces if applicable shall be considered.

Base plates shall be placed on foundation pedestal with grouting. For large base plates necessary grout holes shall be provided. Generally anchor bolts for fastening steel columns on foundation shall be embedded in foundation during concreting itself using suitable templates for correct positioning. No anchor pockets in foundation shall be allowed for anchor bolts in tension. Design of base plates shall be based on design pressure on foundation, which shall not exceed the appropriate bearing values given in IS : 456

The total horizontal shear force at the base of column is transferred to the column pedestals through friction between the base plate and the grout. A co-efficient of friction of 0.30 shall be used in conjunction with the minimum column load, as defined above. If the horizontal shear force exceeds the frictional resistance force shear may be transmitted through bolts or shear keys. If the column is subjected to a net uplift load, the total force shall then be transmitted through shear bars / shear keys welded to the base plate. Necessary recesses shall be kept in the foundation concrete for shear lugs.

Angle sections shall not be used as flexural members except for roof trusses, purlins, side girts and walkway runners.

For axially loaded members in framework, minimum angle section to be used shall be ISA 50x 50 x 6.

End connections for rolled beams, built-up beams etc. shall be designed for a minimum of 75% of their shear capacity and 100% of moment capacity (for moment connection).

Moments shall be considered for design of columns arising due to eccentricity of floor beam connections with column. Minimum eccentricities on column shall be considered as per IS: 800.

For edge protection around cutouts / openings in floor slabs. Minimum angle section to be used shall be ISA 50 x 50 x 6 with suitable anchor lugs.

Toe guards shall have a minimum depth of 100 mm and a minimum thickness of 6 mm.

Hand railing shall be of hot dip galvanized construction out of 32 mm NB pipes of medium class conforming to IS:1161 with threaded ends and necessary bends, tees, elbows, sockets etc. Hand railing shall be 1000 mm high with two horizontal rails one at 500 mm and another at 1000 mm above the base level along with vertical posts spaced at not more than 1500 mm centres.

Where floor beams form part of the vertical bracing system, additional loads from floor beams transferred to bracing shall be taken into consideration in the design.

Minimum width of steel staircase shall be 1000 mm. Minimum width of treads without nosing shall be 250 mm. Maximum height of riser shall be 200 mm and they shall be limited to 16 per flight. Staircases shall be provided with hand railing. Staircase step shall be made out of chequered plate or gratings of presswelded construction designed for a live load of 500 Kg/Sqm.

For any structural steel member, a minimum of 2 nos. 16 mm dia black bolts shall be used for permanent bolted connection and 1 no. 16 mm dia erection bolt for site welded connections.

All foundations bolts shall be provided with one nut and one locknut.

Base plate arrangements of all structural steel columns in buildings shall be so provided that the entire base assembly is below finished floor level. The base plate assembly shall be suitably encased in RCC. For open structures, base plate shall be rest on RCC pedestals, which are 300 mm above finished ground level.

All grouting work below stanchions / bases of equipment shall be with, branded premixed non-shrink free flow grout of approved manufacture which shall have a minimum crushing strength of 450 Kg/cm.Sq. at 28 days.

Minimum thickness of color coated GI sheets to be provided as roofing and cladding shall be 0.5 mm Minimum slope of color coated GI sheet roofs shall be 10 degrees.

#### 9.3.6.3 Materials

Structural steel shall conform to IS : 2062.

Chequered plates shall conform to IS : 3502. Pipes for handrail shall be as per medium grade of IS : 1161. Crane rails and transformer track rails shall conform to IS : 3443.

#### 9.3.6.4 Connections

Generally all shop and field connections shall be welded except for field connections. All moment connections, if bolted shall be of High strength friction grip bolts. Shear and other minor connections, if bolted may be made with mild Steel / High strength bearing bolts.

IS : 816 and IS : 9595 shall be followed for welding of structures. Electrodes of approved makes shall be used.

For high strength friction grip (HSFG) bolt connections, IS:4000 shall be followed. High strength friction grip bolts shall be of property class 8.8 and shall conform to IS : 3757 and shall not be less than 20 mm in diameter. High strength bolts shall be installed as bearing type joint except where loads are reversible.

All other (other than HSFG) bolted connections shall have bolts of minimum 16 mm dia. The connections of stairs and hand railing shall be made with 16 mm diameter threaded fasteners conforming to IS : 1363. Erection bolts shall be black bolts of minimum 16 mm dia.

All bolts and nuts have property class compatible to each other. Bolts carrying dynamic or fluctuating loads and those in direct tension shall be provided with an additional double coil helical spring washer conforming to IS: 6755.

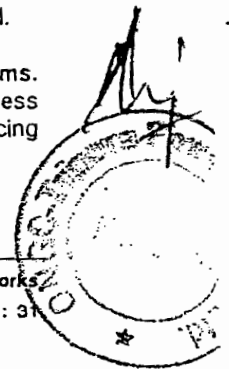
Where a steel beam or member is to be connected on RCC structure, it shall be connected using an insert plate and preferably through shear connection.

For crane girders, full penetration of weld between web plate and top flange shall be ensured.

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

Horizontal bracings shall be angle / tee section located at the bottom of framing beams. Field welding of bracing at the underside of beam as required to meet slenderness requirement of bracing member shall be indicated on the drawings. Horizontal bracing shall be arranged to avoid framing into the beams at columns locations.

Intermittent welding shall not be permitted



**9.3.6.5 Permissible Deflections**

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

**Vertical Deflection**

Beam and Girders : Span / 325 or 20 mm whichever is lesser.

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

For manually operated cranes & monorails : Span / 500

For EOT Cranes < 50T : Span / 750

For EOT Cranes > 50T : Span / 1000

**Horizontal deflections**

Columns : 1/325 of height

Crane Supporting Columns : 1/1000 of height for horizontal surge load.

The maximum horizontal relative displacement due to seismic forces between two successive floors shall not exceed 0.004 times the difference in level between these floors.

**9.3.6.6 Minimum Thickness**

The minimum thickness of various components of a structure and hot rolled sections shall be as follows. The minimum thickness of rolled shapes shall mean flange thickness regardless of web thickness. Structural steel members exposed to marked corrosive environment shall be increased suitably in thickness or suitably protected otherwise as per good practice and sound engineering judgment in each instance.

- |   |   |                  |
|---|---|------------------|
| a. Trusses, purlins, girts and bracing  | : | 6 mm.            |
| b. Columns and beams  | : | 8 mm             |
| c. Gussets  | : | 8 mm             |
| d. Stiffeners   | : | 8 mm             |
| e. Base plates  | : | 10 mm & above    |
| f. Chequered plates   | : | 6 mm o/p & above |
| g. Grating flats  | : | 5 mm             |
| h. Minimum thickness of structural members, other than gratings and chequered plate, directly exposed to weather and inaccessible for painting and maintenance shall be 8 mm. |   |                  |

**9.3.6.7 Minimum sizes**

The flange width of purlins supporting roof sheeting and wall cladding shall not be less than 50 mm.

Width of steel rolled section connected to other member shall be at least 50 mm.

**9.3.6.8 Slenderness and Depth Ratio**

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

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

a. Truss	1/10
b. Rolled beams and girders for ordinary floors and rafters	1/24
c. Supporting floor beams for vibrating machinery / equipments	1/15
d. Roof purlins and girts	1/45
e. Gable columns	1/30

**9.3.6.9 Painting and Corrosion Protection Measures**

Structural steel shall be painted after sand blasting as per specification.

For galvanised structures, rate of zinc coating shall be not less than 0.710 kg/m<sup>2</sup>, unless mentioned otherwise.

**9.3.6.10 Design Criteria for Switchyard Structures and Electrical Gentries**

The tower structures in the switchyard shall be designed as per the recommendations of IS:802.

Diagonal wind/inclined wind shall be considered for isolated self supporting structures like lighting and lightning masts and poles only. Other structures which are interconnected either by beams or rigid bases need not be analyzed for inclined wind loading.

Short circuit forces shall be considered for the structural analysis of tower/structures.

Switchyard structures shall be galvanized.

**9.3.7 Design Criteria – Outdoor Facilities****9.3.7.1 Roads**

All roads shall be well designed Bitumen topped Roads. Berms shall be minimum 1m wide. Red murrum, minimum 150 mm thick shall be provided for Berms.

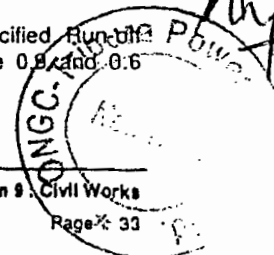
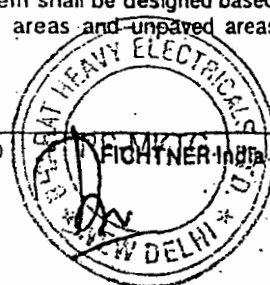
The crown of the road shall be minimum 150 mm above FGL. The final finished roads shall have a camber of 1 in 60. Camber on top of compacted crushed stone soling surface shall be 1 in 40.

Wherever drains or other underground facilities cross the roads, concrete pipe culverts of class NP3 or RCC box culverts shall be provided.

Roads shall be provided with kerb stones and the same shall be painted as per specifications.

**9.3.7.2 Drainage**

Surface drainage system shall be designed based on a rainfall intensity specified. Run-off coefficients for paved areas and unpaved areas shall be assumed to be 0.8 and 0.6 respectively.



A network of open drains shall be provided to carry surface run off which would run along the sides of roads and lead to the nearest natural drain surrounding the plot.

Buildings shall be provided with plinth protection all around, sloped towards side drains. The side drains shall be connected to the main drains on either side of the roads.

For pipe drains, concrete pipe of class NP2 conforming to IS : 458 shall be used. However for road crossing, class NP3 pipe shall be used. If sufficient clearance cannot be provided between the top of pipe and road top, the pipes shall be encased in RCC.

The maximum velocity of drain shall be limited to 2.4m /sec and 1.8m /sec for pipe drains and open drains respectively. However a minimum self-cleansing velocity shall not be less than 0.6m/sec.

For process drains, catch pits shall be provided at the source locations and they shall be interconnected by buried RCC pipelines and connected to oily water system.

No bends and branches shall be allowed in underground pipes. Where change of direction and/or branches are required manholes shall be provided. Distance between Manholes shall not exceed 30m.

Acid cleaning water shall not be discharged into the storm water drains.

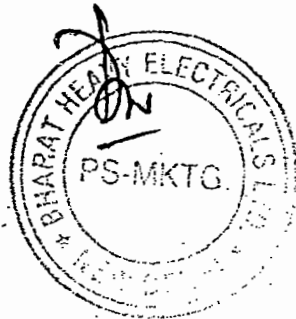
#### 9.3.7.3 Sewerage System

The sanitary sewage system shall be conveyed through underground pipelines by gravity and designed accordingly. Manholes shall be provided at all bends, intersection and in straight stretches more than 30 m long. Sanitary system within the buildings shall be provided as per standards and connected to sanitary disposal system specified elsewhere.

Sewers shall be designed for a minimum self clearing velocity of 0.75 m / sec. Maximum velocity shall not exceed 2.4 m / sec.

#### 9.3.7.4 Oily Water/Waste Water System

A Network of drains consisting of PVC pipes within the buildings and stoneware pipes outside (encased in concrete as required) shall be provided to convey oily water / waste water from the various buildings, transformer outlets, etc. The drains shall discharge into one or more oil water separators. The clear water from the oil water separator shall be let off into the Central Monitoring Basin.



## 9.4 SPECIFIC TECHNICAL REQUIREMENTS AND FUNCTIONAL REQUIREMENTS

## 9.4.1 Topographical / Contour Survey

A contour survey has already been carried out in the Power Plant area and the existing contour lines are shown in drawing enclosed with Tender Documents. Based on the preliminary data of topographical survey, the proposed plot for power plant has an undulating terrain with the ground levels variation from (+) 30.00 m to (+) 17.50 m above mean sea level. The ground level follows abrupt variation in elevation of levels through out the area. The data furnished is for bidding purpose only and it is the Contractor's responsibility to verify the data by carrying out an independent survey after award of work. No time or price implication shall be admissible due to likely variation in site Contours from those furnished in the tender.

For the survey to be carried out by the Contractor, the benchmarks shall be transferred from the nearest permanent benchmark to be identified by the Owner's Engineer. Survey shall also be carried out by the Contractor in the river water and effluent discharge pipeline routes and the River Water Intake area. Spot levels shall be taken at 10 to 15 meter intervals and the contour lines shall be drawn for every 0.25 meter contour intervals. Pipeline survey shall be carried out over a corridor of 10.0 m width along the proposed route with spot levels taken at 25 metre intervals and across at 5.0 metre intervals at the 25 metre intersection points.

The scope also includes providing grid pillars 300 mm x 300 mm x 600 mm in pre-cast concrete of grade M15 at 200 m intervals with theodolite points marked on embedded plates, throughout the entire project area. The co-ordinates & levels shall be etched & painted with indelible ink. The foundation for the pillars shall be suitable for the soil condition but not less than 1.0 m deep.

## 9.4.2 Geo-Technical Investigation

Preliminary Soil Investigation has been carried out in the Power Plant Area. Copy of the same is attached to the tender. This is intended to give an idea of the soil conditions prevailing at site. However, a detailed Soil Investigation shall be carried out by the contractor to verify the data provided and to finalise the foundation concept and type of foundations. Any variation in soil conditions and foundation parameters from those indicated in tender documents shall be incorporated in the final design without any cost or time implication.

The investigation shall cover sufficient no. of bore holes in each area to get a longitudinal section of the soil profile, cone penetration tests and laboratory tests to obtain the engineering properties of soil including dynamic properties for areas where GTG, STG, Boiler Feed Pumps etc are to be located. Wherever the structures are to be supported on piles, the boreholes shall extend upto hard rock. The investigation and report shall be in line with the technical specification for soil investigation covered in Section 8.5.

Preliminary Soil Investigation indicates the presence of medium stiff to stiff silty clay in the top stratum of depth varying from 4 to 6 metres from the existing ground level. This is followed by dense to very dense clayey silty sand layer till about 20 metres from ground level. Based on the above shallow spread foundation may be feasible for auxiliary buildings / structures and non-plant buildings. STG & GTG foundations, major equipment foundations and chimney may require pile foundations to limit settlement to allowable units.

Ground water table level shall be taken at 2.0 metres from finished ground level or higher as per final soil investigation report, for design of underground structures.

**9.4.3 Boundary Wall**

Boundary wall of masonry work shall be constructed by Owner around the power plant area along the property line. The elevations of the boundary wall has been fixed by Owner based on the formation level finalised for different area.

**9.4.4 Site Grading**

Site grading level shall be fixed with due reference to site drainage, maximum flood level and system requirements. Based on the spot level and contour survey done, the formation levels as finalised is attached in the site grading plant, enclosed. Bidder's can propose different site grade level and any changes warranted consequent to such grade level changes on the boundary wall shall be modified by the Contractor without any liability to Owner.

The area shall be suitably cut and filled to suit the layout requirement. The Contractor may provide terraced grading, considering the large variation in existing ground level.

After performing the optimisation of levels from the detailed site survey by the Contractor, the final formation level of the plot at various areas shall be finalized.

Fill shall normally be made up of Cohesive Non swelling material capable of being compacted upto 95% Modified Proctor density. Filling may also be made using dredged sand in which case a relative density of 85% shall be achieved. In case earth has to be borrowed from outside the plant boundary, the same shall be arranged by the Contractor himself. Earth from Swamps, marshy as well as logs, expansive type of clays, peats, organic material, material susceptible for combustion, material which will react with other material already used in work shall not be used as borrow material. The slope at the edge of graded areas shall not be flatter than 1:1.5 (1 vertical to 1.5 horizontal) in cutting and 1:2 in filling.

**9.4.5 Roads, Paving, Drainage & Sewerage****Roads**

The main road to the Power Plant shall originate from the main approach road. The main road shall be 7.0 m wide with 1.5 m wide berm to accommodate large truck movement. Branch roads may be of single lane and 4.0 meter wide with 1meter wide berm on either side.

Patrol roads along the boundary shall be minimum 3.0 m wide and shall be of WBM.

The minimum recommended road section is as follows :

- |          |   |   |
|----------|---|---|
| Sub-base | : | Sub base shall consist of stones of 150 mm maximum size in two layers compacted to a thickness of 230 mm.                                   |
| Base     | : | Base shall have a thickness of 225 mm consisting of 3 layers of 75 mm each (compacted thickness).   |
| Topping  | : | The bituminous surfacing shall consist of wearing course of premix carpet 20 mm thick over binder course of 50 mm thick Bituminous Macadam. |

Initially only water bound macadam surface shall be constructed and after completion of the project but before COD, the damaged portions of the road shall be repaired and the bitumen topping shall be carried out.

The thickness given above is the minimum requirement and it shall be checked and confirmed by the Contractor as per design requirements based on CBR value of the subgrade. All roads should be designed in accordance with IRC 37-2001 for a traffic intensity of 1500 vehicles per day.

#### Paving

HRSR area shall be paved with RCC slab, 100 mm thick in grade M20. 230 mm thick rubble soling shall be provided below the paving. Higher thickness as per design shall be provided in areas of vehicular movement. Top of paving shall be kept 100 mm below FFL.

#### Drainage

Surface drainage system shall be designed based on a rainfall intensity of 100 mm/hr.

Grade level shall be fixed with due reference to highest high flood level of the receiving body of water. Contractor shall identify the receiving body.

Drainage scheme with detention ponds which allows for groundwater recharge & maintains the existing drainage pattern as far as possible is desired. A network of open drains will be provided to carry surface run off which would run along the sides of roads. Final discharge will be to nearby natural drain. Bed slope not milder than 1 in 1000 shall be provided.

Buildings shall be provided with plinth protection all around, sloped towards side drains. Side drains shall be of brickwork covered with perforated precast RC slabs. The side drains shall be connected to area drains by either open drains or combination of open drains and under ground pipes.

Main drains on either side of roads shall be of trapezoidal shape lined with concrete slabs or bricks. Base of the drain shall be of 150 mm thick PCC in grade 1:3:6.

#### Sewerage system

Sanitary sewage generated from the toilets shall be connected to Septic tanks located in the respective areas. The effluent from the Septic tanks shall be treated in Soak pits or dispersion trenches.

#### 9.4.6 Pre constructional Anti termite treatment

Pre-constructional anti termite treatment shall be given to all vulnerable areas susceptible to termite attack and shall include column pits, wall trenches, foundations filling below the floors etc. as per IS : 6313 and other relevant Indian Standards.

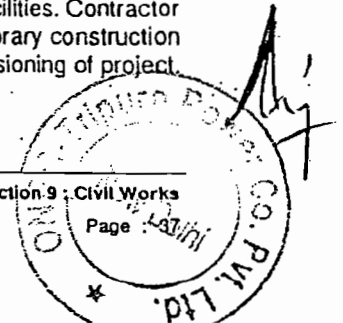
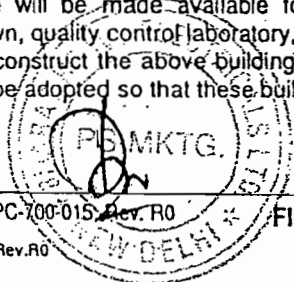
#### 9.4.7 Construction Facilities

##### Construction Water & Power

The contractor shall make provisions for construction water and Power as required during construction phase. The water / power outlets shall be distributed all over the plant for easy tapping in different areas.

##### Site office and other facilities

Space will be made available for the Contractor to construct his site office, cement godown, quality control laboratory, stores (closed and open) and other facilities. Contractor shall construct the above buildings and facilities at his own cost. Temporary construction shall be adopted so that these buildings can be demolished after commissioning of project.



Necessary temporary roads shall also be constructed by the Contractor. The quality control laboratory shall have facilities for testing all construction materials and other necessary tests to ensure field quality control.

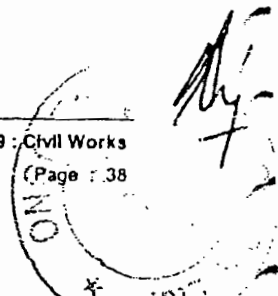
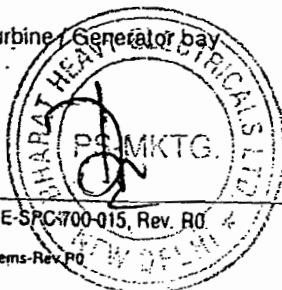
All amenities to Contractor's workers, such as canteens, toilets, drinking water, rest places, creche etc., shall be provided by the Contractor.

#### 9.4.8 Architectural and Finishing Requirements

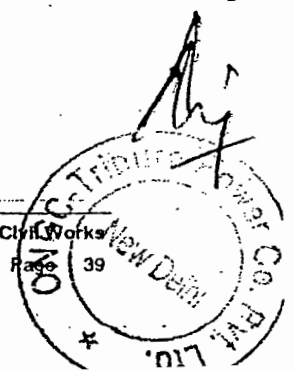
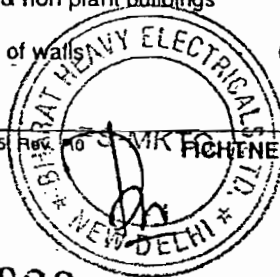
Reference shall be made to Clause 8.3.2.3 for specification/thickness of the various Architectural finishes indicated below:

##### Floor Finishes

Ground Floor (of all plant buildings) - Switchgear rooms, Operating floors	- Indian Patent Stone (IPS) with non-metallic hardener topping
Operating floor (For Powerhouse)	- Indian Patent stone with non-metallic hardener topping
Control room	- PVC / Rubber based or homogenous vinyl tile flooring on false floor
Battery room	- Acid resistance tile flooring and dado (2.2 metres)
Offices	- Pre-cast terrazzo tiles / PVC tiles
Toilet	- Ceramic Tiles
Oil, Acid & Alkali-spillage areas	- Acid / Alkali & Resistant tiles
<b>Non-Plant Buildings :</b>	
Passages and lobby	- Marble Flooring
Other Areas	- PVC tiles / unglazed ceramic tiles
<b>False Ceiling</b>	
Control room	- LUXALON or equivalent
Office areas	- Fire resistant Particle board
<b>Roof finishes</b>	
All Buildings	- Polymeric membrane based waterproofing
<b>Joinery</b>	
- Windows	
Turbine / Generator bay	- Glazed, operable windows with aluminium frame



Control room	- Glazed, fixed windows with aluminium frame with double glazing for outer windows and windows facing turbine bay and with single glazing for internal windows / partition
Switchgear room	- Glazed, fixed windows with Aluminium frame
Offices	- Glazed, openable windows with Aluminium frame
Other buildings	- Glazed openable / fixed windows with Aluminium frame
<b>- Doors</b>	
Control room	- Fully glazed doors with aluminium frame
Offices	- Fully glazed doors with aluminium frame
Toilets	- Timber panelled doors with Teakwood frame and marine board panel with laminated plastic sheet on the inside face. or PVC doors
All other doors in Plant Buildings	- Double plated steel doors
Fire barrier doors	- Specially designed double plated steel doors with insulation having 2 hours fire rating.
Non plant buildings	- Timber flush doors with teak wood frame or Fully glazed doors with Aluminium frame.
<b>- Painting</b>	
Structural steel	- Chlorinated rubber paint after shot blasting
Metal and Timber Joinery	- Synthetic enamel paint
All Ceiling	- Oil bound distemper (office rooms without false ceiling)  Acid resistant resin based Epoxy coating over two coats of DECKURDS-S manufactured by FOSROC or equivalent (Battery rooms)  White washing (all other areas)
Internal wall surfaces	
Control room/office	- Acrylic Emulsion
All other rooms in plant buildings & non plant buildings	- Oil bound distemper
External faces of walls	Cement based water proof paint



Walls of battery room and other acid/alkali spillage areas

- Chlorinated rubber paint on exposed walls above Dado.
- 2100 mm high Dado of Acid / Alkali resistant tiling

#### Metal Cladding

STG & GTG Building

- Double skin permanent colour coated sandwiched insulated metal cladding system

Other buildings (where metal claddings is specified)

- Single skin permanent colour coated (non-insulated) metal cladding system

A standard colour scheme for the different buildings/structures shall be prepared by the Contractor and the approval of the Owner shall be obtained, before commencement of work.

#### 9.4.9 Steam Turbine Generator (STG) Building

The dimensions of the Power house shall be decided by the Contractor based on layout considerations.

STG Building and the adjacent Electrical room building shall be a steel framed structure with rigid frames in the transverse direction and braced frame in the longitudinal direction. The roof over turbine bay shall be of cast-in-situ RCC slab laid over permanent metal decking, supported on steel roof truss. Crane girders shall be plate girders built up from plates designed for the vertical wheel loads and lateral surge loads. Main columns shall also be built up from plates. All floors shall be of cast-in-situ RCC, supported on steel beams. Erection openings above equipment shall be covered with GI gratings (min 40 mm thick). STG Building columns shall be supported on Pile/isolated spread foundations depending on the final soil investigation report. Side cladding around STG bay shall be of double skin colour coated sandwiched insulated metal cladding above 3.0 metres. The cladding from Ground floor to EL(+) 3.0 metres shall be of 230 thick brickwork. In Electrical bay, the entire height shall be cladded with brickwork. Fire protection walls shall be of thickness to satisfy TAC requirements. Wall beams shall be of steel, encased in concrete with necessary sunshades.

STG Building shall be provided with openable windows on external walls at each floor level. Continuous fixed windows shall be provided above crane girder level. Double doors with air lock shall be provided for Control Room. Rolling shutters shall be provided for large openings meant for equipment entry and which are not in frequent use. Electrically operated rolling shutters shall be provided for very large openings as per BIS and tender specification. At least one door each in electrical, control and control equipment room shall be sized to accommodate the largest size of transportation module of panels. Provision for lifting of panels shall be made for erection of panels.

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

Control room will be centrally air conditioned and shall have false-ceiling and min 600 mm deep false floor.

The location, numbers, dimension of access doors, rolling shutters, stairs etc., shall be decided based on layout, operational & maintenance requirements and shall also take into requirements of factory act, and fire safety / protection requirements. Fireproof doors shall be provided at all fire exits with a fire rating of 2 hours. Fireproof enclosure shall be

provided for one of the external stairs which shall connect all floors. Cable galleries shall be provided with fire proof walls rated for 2 hours. Requirement of stairs shall be as per TAC recommendations.

In the ground floor, drains and sumps shall be provided to drain water from fire hydrant system, process discharge etc. which shall connected to oily water system.

The service and potable water tanks shall be provided on the roof of the Electrical bay.

Toilet block shall be located close to the control room and other areas of concentration of operating personnel. The numbers and sizes shall be decided by the number of users as per IS:1172 and other general requirements specified.

In addition provision shall be given for tool rooms and cabins for operating staff in the various floors.

Finishing shall be as specified under Architectural & Finishing requirements.

STG building shall be supported on piles.

#### 9.4.10 Gas Turbine Generator (GTG) Building

GTG building shall be steel framed building with rigid jointed portal frames in the transverse direction and pin jointed braced frames in the longitudinal direction.

The building shall have 230 thick brick cladding upto 3.0 metres from floor level and double skin insulated metal cladding above. Roof shall be of cast-in-situ RCC laid over permanent metal decking.

One row of continuous windows shall be provided at ground level and above crane girder. The ground floor slab shall be designed to withstand heavy vehicle movement. Suitable floor drainage arrangement with drain pits and buried pipes shall be provided and the same shall be connected to only water system.

GTG building shall be supported on piles.

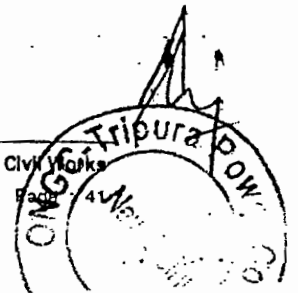
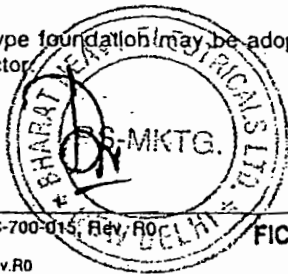
#### 9.4.11 Gas Turbine Foundation Steam Turbine Foundation and Other Equipment Foundations

##### STG Foundation

The Contractor shall choose between the following two types of foundation systems based on techno- economic considerations. The type of foundation offered shall be indicated in the bid document.

- a) Conventional framed foundation in RCC, isolated from other structures of Power House.
- b) Spring mounted foundation with inertia block supported on RCC structure isolated from the building frame.

Block type foundation may be adopted depending on the type of machine offered by the Contractor.



**GTG Foundation**

The Gas Turbine Generator foundation shall be a rigid mat foundation.

STG and GTG foundations shall be supported on piles. The Contractor shall furnish detailed calculations containing loading data (static and dynamic), general arrangement drawings and detailed dynamic analysis (free and forced vibration analysis) for Owner's Engineer's approval. The model considered for analysis shall take into account pile/soil/structure interaction.

**Other Equipment Foundations**

Foundations for other major equipment such as HRSGs, Boiler feed pump etc. shall also be supported on piles to avoid differential settlement. Type of foundation for other equipment foundation shall be based on the recommendations of the final soil investigation report. Spring supported foundations shall be provided for low frequency machine foundations wherever the same are required from technical considerations. Dynamic analysis calculations shall be submitted for approval.

All the machine foundation structural components shall be tested for voids using Non destructive (NDT) methods as per the recommendations of IS:13311, as required by the Owner's Engineer.

**9.4.12 Transformer Yard**

Heavy Transformer foundations such as Generator Transformers, Unit auxiliary transformers / Station transformers / Inter Connecting Transformers shall be founded on piles/isolated spread footings depending on the final soil investigation report. Individual transformer foundations shall have its own pit which would cover the area of the transformer and cooler banks, so as to collect any spillage of oil or oil drainage in case of emergency. The oil pit shall be filled with granite stones of 40 mm size uniformly graded. The individual oil pits shall be connected to an oil collection pit which shall be sized to accommodate oil volume of the largest transformer connected to it, without backflow. The oil pit shall be connected to oily water drainage system. Dimensions of the discharge pipe shall consider rainfall intensity also. The water shall be discharged into the nearest drain by gravity flow or pumping.

Local rail track shall be provided from the nearest road for movement of the generator transformers to the foundation location. Rail track foundation shall incorporate jacking pad foundation at intersections of rail racks. Pulling hooks shall be provided at suitable locations for pulling the transformer over the rails.

The area around the transformer shall be covered with gravel and galvanised chain link fence with fence posts and gates shall be provided. The portion of the fence covering the rail track shall be made of removable type for movement of transformer during erection/removal. Alternatively, gate with provision for locking shall be provided. For small transformers of width not exceeding 5 metres, a gate shall be provided for access of transformer. In addition a small gate, 1.2 m wide shall be provided for man entry. The gates shall have provision for locking.

**9.4.13 Local Electrical/Control Rooms**

The dimensions of the buildings shall be decided by the Contractor from Equipment Layout considerations.

Local Electrical / Control rooms for DM Plant CW Pump house etc., shall be of RCC construction with plastered brick cladding. Windows and doors shall be of fully glazed type with aluminium box frames. Control rooms will be air conditioned and shall have false floor (where no cable cellar is provided) and false ceiling. In electrical-rooms, rolling shutters

shall be provided for equipment entry. Electrical rooms and control rooms in upper floors shall have provision for lifting of panels and the equipment access door shall be suitably sized to accommodate the largest transportation module of panels. Cable trenches shall be of RCC construction and with pre-cast RCC covers, where no panels are located. Where panels are located, chequered plate cover shall be provided over the balance width not occupied by panels. Sufficient slope shall be provided in the base slab of cable trenches to drain out seepage water/floor wash water. A sump shall be provided in the deepest stretch of trench and the drains shall be sloped towards the sump. The sump shall be connected to the nearest drain by gravity flow (if possible) or by pumping. Wherever the cable trenches inside the building join with or are continuous with external yard trenches a barrier RCC wall shall be provided at the periphery of the building and pipe sleeves shall be provided in the wall for cable entry. The annular space between the pipe sleeve and the cables shall be sealed after erection of cables.

Sufficient office space and toilet facilities shall be provided for operating personnel.

#### 9.4.14 Steel Chimney.

A single flue steel chimney shall be provided for each HRSG. Exterior insulation shall be provided using mineral wool of necessary thickness. This insulation shall be provided upto at least one-third (1/3<sup>rd</sup>) of height of the stack from the grade level, as a minimum. Necessary access doors shall be provided for personnel movement. Helical strakes shall be provided at the top (usually 1/3<sup>rd</sup> height) if found necessary from design requirements. Painting of steel surfaces shall be carried out as per specification.

The chimney shall be supported on a foundation system with piles.

The design of the chimney shall be as per the recommendation of IS:6533.

Daylight aviation warning shall be provided by painting alternate bands of red and white from the top of the chimney for the required height, as required by statutory regulations. Aviation warning lighting system shall conform to the requirement of the latest applicable rules of International Civil Aviation Organisation (ICAO) and NAA/DARA regulations. Necessary platforms and ladders shall be provided to access the same.

Sampling ports for NO<sub>x</sub> and SO<sub>2</sub> analysers shall be provided on the chimney shell as per Pollution Control Board requirements.

#### 9.4.15 Water Treatment Plant

DM water Plant vessels and exchangers shall be located in a steel framed shed with single skin metal roofing. The entire area shall be suitably paved.

Acid/Alkali storage shall be separated with a kerb and the flooring shall be lined with acid / alkali resistant tiles. The drains from the exchangers and vessels discharging into the neutralisation pit shall be lined with acid/alkali resisting tiles. Neutralisation pit shall be designed as a water-retaining structure with external polymeric membrane based water proofing and internal lining with acid / alkali resistant brick lining. The discharge from the neutralisation pit shall be pumped into Central Effluent Monitoring Basin.

DM Water tanks located outside shall be supported on sand pads with ring wall. The foundation system chosen shall limit the differential settlements.

#### 9.4.16 Gas Compressor Building

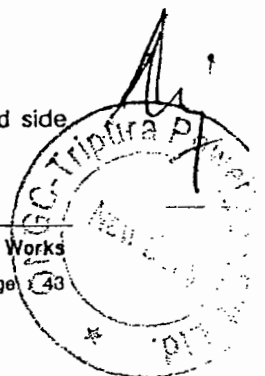
Dimension of the building will be decided by equipment layout considerations.

The building will be of steel construction with single skin metal sheet roofing and side cladding.



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Gas compressor foundations shall be isolated from the adjacent floor. Necessary cable / pipe trenches and drain pits as required for system requirements shall be incorporated in the ground floor.

#### 9.4.17 Switchyard

Dimensions of the switchyard shall be decided by the Contractor from equipment / layout considerations.

Towers and supporting structures shall be of galvanised steel. Rate of galvanising shall be 900 grams per square meter. Design of towers and supporting structures shall be as per IS : 802.

Fencing of 3.0 m height (chain link fencing) including three strands of barbed wire shall be provided all around the switchyard.

A minimum of 100 mm thick crushed stone shall be spread in the switchyard area extending one meter beyond the fence. Necessary drainage arrangement to take care of on line cleaning water shall be provided. A double swing gate of adequate width (Minimum 3.5 m wide) and a wicket gate shall be provided. Gates should not be self locking.

Necessary switchyard control building shall be provided which shall be of RCC framed construction with brick cladding. Necessary office space and toilet facilities shall be provided for the operating personnel in the switchyard control building.

#### 9.4.18 Pipe/Cable Racks & Trenches

Pipe / Cable Rack shall be of Steel Construction and shall be single / multi-tiered as required. The cable tray supports shall be provided above the topmost pipe tier. Minimum clearance to the lowest tier of pipe rack shall be 2.5 m in general and 6.5 m under road crossings.

Pipe / Cable trenches shall be of RCC Construction with precast RCC cover slabs. The trenches shall have cross slope and longitudinal slope and shall be connected to drain pits at maximum 100 metre intervals. The drain pits shall have provision for fixing mobile submersible pumps.

Pipe rack carrying power cycle pipes shall be supported on piles.

#### 9.4.19 Workshop & Store

Dimension of the building shall be decided by the Contractor from equipment layout and storage considerations.

The building shall be of steel framed structure with single skin metal roof sheeting. Side cladding shall also be of the same type. The ground floor slab shall be made of abrasion resistant finish suitable for light to medium vehicle movement. Provision for office space and a toilet block shall be made, which shall be of RC construction with brick cladding.

An open storage yard shall be provided outside the building with security fence all around.

#### 9.4.20 River Intake

The source of plant Raw Water will be River Gumti, located about 2.0 km from the plant. The system envisaged for raw water drawal is sub-surface Infiltration system. Water will be drawn in from under the river bed through adequate numbers of suitably sized perforated Infiltration pipes connected to a buried Infiltration well. The Infiltration well is connected to a Jackwell located on the banks of the river through Intake Pipe buried in the river bed. The Pumphouse will be located above the jackwell. The Jackwell, Infiltration wells and the Pumphouse shall be of RCC Construction. The pipes buried in river bed

shall of material suitable for the service condition and having adequate structural rigidity to withstand the soil overburden. The conceptual scheme of Intake is shown in drg. No. 10-6725-M-004 enclosed with the tender documents.

Contractor's scope includes conducting necessary studies and investigation to obtain the river bed characteristics, ground water potential, data regarding the seasonal variation of flow in River Gomti and all other data necessary to identify the location of River Intake, decide on the type of Intake and to size and design the same. The scheme shown in the Tender drawing is only a suggested concept and it is the Contractor's responsibility to verify the feasibility of the system and propose alternative solutions, if required, to ensure adequate raw water supply to the plant. No extra claim on this account will be admissible.

#### 9.4.21 Raw Water Reservoir

Raw Water Reservoir shall be formed by earth excavation and using the excavated soil earthen bunds shall be formed all around. The side slope of the bund shall not exceed 1:2 (1 vertical to 2 horizontal). The top width of bund shall be 4.0 m wide and shall be motorable. Water bound macadam road shall be provided. The inner slope shall be lined with heavy duty LDPE black film of 250 micron thick conforming to IS :2508. LDPE liner shall be topped with 25 mm thick precast concrete tiles of grade M15 or brick tiles laid in 1:5 cement mortar 15 mm thick. Joints in tiles to be sealed with cement mortar (1:3). The base of the reservoir shall be provided with 50 mm sand cushion over which the LDPE liner shall be laid. 300 mm thick impermeable clayey layer shall be provided over the film. The clayey layer shall be of non-swelling type. In case clayey layer is locally not found, cement concrete tiles on mortar shall be laid over the film as adopted for the sloped surface.

The LDPE film provided on the sloped surface shall be suitably anchored at the top of bund and also at the bottom to ensure that the film does not slack. Openings in LDPE film for pipes etc shall be suitably sealed to prevent water leakage. The outer slope of the bund shall have a slope not exceeding 1:1.5 (1 vertical to 1.5 horizontal) and shall have turfed finishing.

#### 9.4.22 Raw Water Pump House

The pumphouse shall be located in one corner of the Raw Water Reservoir. The forebay of the pumphouse shall be formed by cutting into the bund and shall be of RC construction. The pumphouse shall consist of a wet sump below ground. The arrangement and construction of the Pumphouse shall be similar to CW Pumphouse.

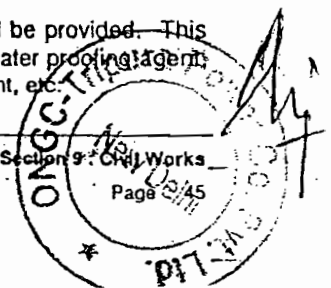
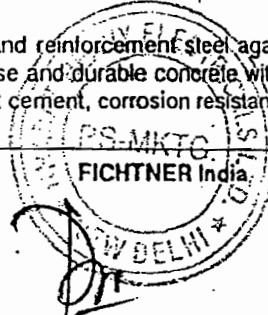
#### 9.4.23 CW System

CW Pumphouses shall house the cooling water pumps as well as ACW pumps for GTG and STG auxiliaries. Necessary forebay and sump accommodating the trash racks, stoplogs including the handling arrangements shall also be provided in the CW Pumphouse. Forebay shall be provided with pressure relief valves and designed for uplift of 50% of the water head due to ground water. Super structure of pumphouse shall be of RCC frame work with cast-in-situ RCC roof slab. The cladding shall be of brick work supported on wall beams. Plastering and painting would be provided as per functional requirements.

For CW Chlorinating requirements, a separate Chlorine cylinder storage and CW chlorination equipment room shall be located in a RCC frame structured building.

The IDCT shall be of RCC framed structure. RCC cold water channel to convey cold water from cooling tower basins to CW Pumphouse shall also be provided.

Protection of concrete and reinforcement steel against corrosion shall be provided. This shall include use of dense and durable concrete with plasticizer cum water proofing agents, use of sulphate resistant cement, corrosion resistant steel reinforcement, etc.



**9.4.24 Service / Potable Water Overhead Tank**

One (1) number, potable water overhead tank of adequate capacity shall be provided for storing potable water. It shall be of RC construction and in the shape of an inverted frustrum of cone. It shall be located at a height of 25 metres and supported on an RC cylindrical shaft. RC staircase shall be provided in the annular space of the shaft support for access to the tank. The distribution of potable water from the overhead tank to various areas shall be by gravity.

**9.4.25 Clarified Water Storage Tank and Pumphouse**

One (1) no., partly above ground RCC clarified and fire water reservoir shall be provided in plant area for storing clarified water. The clarified water storage tank shall also provide necessary reserve storage for fire water system.

One (1) number clarified water pumphouse shall provided adjacent to the reservoir which would house DM plant feed pumps, Service water pumps and CW make-up pumps. Sub-structure and superstructure of the pumphouse would be similar to that of the Raw water pumphouse.

**9.4.26 Misc. Plant Buildings**

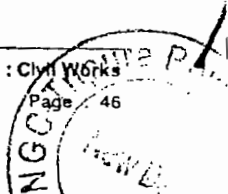
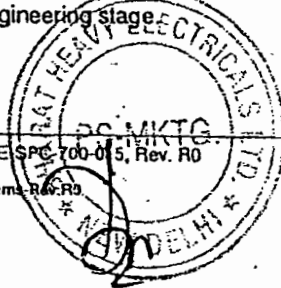
All miscellaneous plant buildings shall be of RCC construction with brick cladding. Glazed steel windows and steel plated doors shall be provided. Floor finish shall be of non-metallic hardener over IPS.

**9.4.27 Non Plant Buildings and Structures****9.4.27.1 Non Plant Buildings**

Non plant buildings covered under the scope are :

Site office for Owner / Owner's Engineer use	-	400 sq.m
Administration Building	-	1200 sqm
Canteen	-	600 sqm
Security office	-	100 sqm
Gate House	-	50 sqm
Training centre	-	1000 sqm
Trainee Hostel	-	1500 sqm
Medical centre	-	700 sqm
Fire station	-	200 sqm
Drill Tower	-	As per Fire Dept's requirements

Detailed requirements and facilities to be provided shall be furnished during detailed engineering stage.



The Contractor shall prepare at least two schemes (coloured perspective views) for each of the above buildings for Owner's approval before proceeding with detailed plans and designs. The layout shall be prepared keeping in mind the plinth area indicated above and shall not be less than the area indicated.

All buildings shall be of RCC framed construction with brick cladding. Finish schedule shall be as indicated under Architectural & Finishing works. Toilet facilities and fixtures shall be decided based on the number of users as per the relevant IS codes / NBC / Factories Act.

3.0 m high chain link fence with gate and gate house shall be provided separating the Non-Plant area and plant area.

#### 9.4.27.2 Parking Sheds

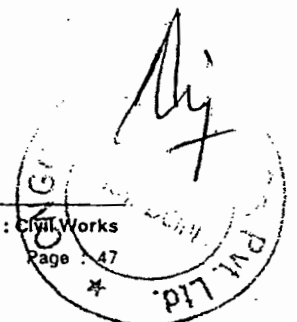
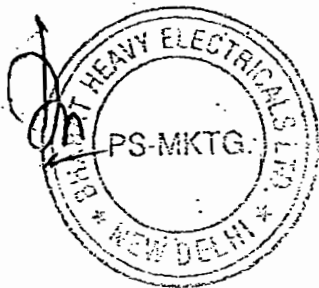
Two wheeler and car parking sheds shall be of pre-cast RCC 'Y' shaped frames with colour coated single skin sheeted roof. Flooring shall be paved with pre-cast cement blocks. Recess for cycle parking to be provided. Parking area to be provided shall be as below :

Car parking	-	225 sqm
Two wheeler parking	-	200 sqm
Cycle Parking	-	300 sqm

#### 9.4.27.3 Watch Towers

Watch towers shall be of latticed steel construction. Height of tower shall be 20 metres. 1.0 m wide platform shall be provided at the top. Access to watch tower shall be provided in the form of 600 wide steel stair. The stair arrangement shall have local landing at 5 metre intervals.

Towers shall be provided at spacing not exceeding 300 metres along the boundary wall and also at all corners.



**9.5 STANDARD TECHNICAL SPECIFICATION FOR CONSTRUCTION****9.5.1 Soil Investigation****9.5.1.1 Scope**

This specification describes the methods and procedures for soil boring, field and laboratory testing of soil samples. It also outlines the contents of the soil report.

**9.5.1.2 Codes and Standards**

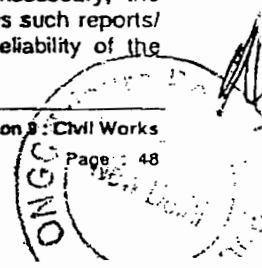
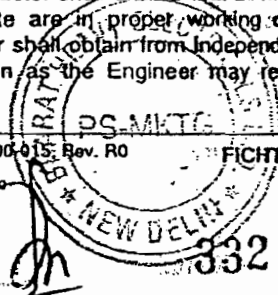
Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship and methods & procedures of testing. Some of the relevant available codes are listed here under.

- IS: 445 Presentation of drilling information and core description in foundation investigation.
- IS: 1498 Classification and identification of soils for general engineering purposes
- IS: 1888 Method of load tests on soils
- IS: 1892 Code of practice for sub-surface investigation for foundations
- IS: 2131 Method of standard penetration test for soils
- IS: 2132 Code of practice for thin-walled tube sampling of soils
- IS: 2720 Methods of test for soils (ALL PARTS)
- IS: 2809 Glossary of terms and symbols relating to soil engineering
- IS: 2810 Glossary of terms and symbols relating to soil dynamics
- IS: 4078 Indexing and storing of drill cores.
- IS: 4968 Method of sub-surface sounding for (ALL PARTS) soils
- IS: 5249 Method of test for determination of in-situ dynamic properties of soils
- IS: 5529 Code of practice for in-situ permeability tests
- IS: 9214 Method of determination of modules of subgrade reaction (k-value) of soils in field
- IS: 10060 Code of practice for subsurface investigation for power house sites

In the event of any conflict between the requirements in the specification and the above referred codes, the former shall govern.

**9.5.1.3 Equipment and Personnel**

The Contractor shall ensure that all machinery, equipment, instruments, etc., mobilized by him at site are in proper working order and accurately calibrated. If necessary, the Contractor shall obtain from independent and approved testing laboratories such reports/certification as the Engineer may require to satisfy himself about the reliability of the



Contractor's machinery, equipment, instruments, etc. The Contractor shall ensure that the field investigation and laboratory work are performed by competent technical personnel and labour who are specifically qualified and experienced in soil investigation work.

Interpretation and recommendation shall be the direct responsibility of the experienced senior technical personnel in the Contractor's organisation.

#### 9.5.1.4 Setting Out

The Contractor shall be responsible to perform the necessary survey work to locate the bore holes/test locations on ground and obtain the ground levels at these locations with respect to the grids and bench mark provided by the Owner/the Engineer.

#### 9.5.1.5 Boring through Soil

The method and diameter of boring shall be approved by Engineer. Minimum diameter of bore hole shall be 150 mm. Uncased holes are permitted only upto a depth where the side can stand unsupported. In case of side fall is noticed, the holes shall be stabilized immediately by using bentonite slurry or providing casing pipes as directed by the Engineer.

Water shall not be added while boring above water table level. Mud circulation/bentonite slurry shall not be used in the bore holes from which water sample is to be collected for analysis.

Casing pipes, where used, shall be stopped 150 mm short of the bottom of the bore at any stage of boring, particularly before collection of undisturbed samples or before conducting Standard Penetration Tests.

Bore holes shall generally be sunk upto the hard stratum or to a depth of 25 m below the ground level whichever is earlier, unless otherwise instructed by the Engineer. Drilling must be continued into rock or hard stratum having SPT value more than 75 for at least two bore holes. If rock/hard stratum having SPT value more than 75 is met with at a shallower depth, it shall be ensured that it is really the rock/hard stratum by continuing the boring into the stratum by 3m. Drilling in rock shall be carried out by rotary core drilling described under Rock Drilling.

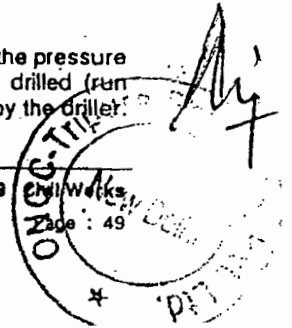
The Contractor shall send copies of daily boring records to Owner and the Engineer at the end of each day. These records shall include the field observations with regard to visual description of soil strata, level of ground water table, drilling fluid consumption, presence of lime, mica, etc. Bore holes shall be backfilled with bentonite/mud cement grout after all samples and other information are obtained from the bore holes.

#### 9.5.1.6 Rock Drilling

During boring operation, once the rock strata is encountered, the normal method of boring operation as described earlier shall have to be stopped and drilling operation shall be resorted to for determining depth and nature of rock strata, in a manner as described below.

Rotary core drilling technique with continuous core recovery should be adopted for drilling through rock. The behaviour of rock mass is governed more significantly by the nature of fractures in the rock than by the type and hardness of the material composing the rock itself. Hence, good drilling technique should be adopted to obtain an intact sample truly representative of the in-situ material and for achieving highest percentage of recovery possible.

Variations in the speed of rotation, the downward pressure on the core barrel, the pressure at which the drilling fluid is introduced into the hole and the length of hole drilled (run length) prior to removal of the core are major items which must be controlled by the driller.



In general, coring should be initiated with short runs because the upper portions of rock masses are commonly highly fractured and also because the elevations of any core losses can be more accurately determined. If conditions indicate that it is possible, the length of the runs may be determined by the length of the core barrel.

In zones which are highly fractured or where the barrel continuously becomes blocked, it is essential that short runs be used even though this means removal of the entire string of drilling tools every 300 mm. or less. Reduced bit pressure should be resorted to when rod vibration or chatter occurs. The pressure under which the drilling fluid should be introduced into the hole shall be the minimum to be consistent with adequate removal of cuttings from the hole and proper cooling of the bit. To minimize the erosive action of the drilling fluid on the core and thereby to improve core recovery, double tube core barrels should be used. The casing and core barrel to be used shall be of designation BX or NX.

During the drilling operation for each bore hole the Contractor shall record the rate of sinking of drill rods, ground water table elevations, if any, nature, type and sequence of rock drilled. From the recovered cores, the Contractor shall determine nature of fractures and degree of weathering of the rock for each bore hole. The Contractor shall also note and record any appreciable loss of drilling fluid throughout the entire drilling operations for each bore hole. The Contractor shall also determine the percentage recovery ratio and rock quality designation from the recovered cores for each stage of core advance and for all the bore holes.

The Contractor shall furnish all the informations mentioned above fully verified and signed by the Engineer at site and submit them in triplicate to the Engineer.

The drilling operation shall be terminated either 3 metres in hard rock or 95% of core recovery whichever is later.

In addition to the above mentioned points, the Contractor shall also take into consideration the provisions of the latest revisions of the relevant BIS Codes of Practice along with Amendments, if any.

#### 9.5.1.7 Collection of Samples

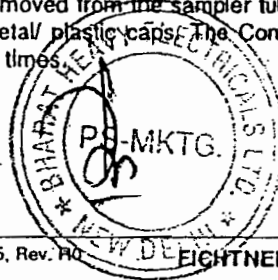
##### Sampling Depths

Soil samples shall be taken generally at intervals of 1.5m and each change of strata in bore holes. Disturbed and undisturbed samples, wherever possible shall be collected. All samples collected shall be suitably and uniquely labelled.

##### Undisturbed Soil Samples

Soil samplers shall conform to relevant Indian standards. Undisturbed samples shall be 90 mm in diameter and 450 mm long. The type of sampler shall be appropriate for the soil to be collected. The undisturbed samples need not be collected when the SPT value is greater than 50.

All care shall be exercised by the Contractor not to disturb the soil during sampling operation. The sampler shall be forced in one continuous motion, not driven, into the ground below the casing. The sample shall be shipped to the laboratory in such a manner as not to cause any disturbances to or loss of moisture from the sample. The soil sample shall not be removed from the sampler tube and the ends shall be filled with paraffin and sealed with metal/ plastic caps. The Contractor shall have, at site, adequate number of samplers at all times.



**Disturbed Soil Samples**

Disturbed soil samples shall be collected from thin walled samplers or split spoon samplers of SPT. The samples shall be collected in air tight jars.

**Ground Water Sample**

Ground water sample shall be collected from any three of the bore holes. Care shall be taken to ensure that no other extraneous water, slurry or storm water, etc., gets mixed with natural ground water in the bore hole before collection. One litre of ground water shall be collected in clean and air tight container to be sent to the laboratory for immediate testing.

**9.5.1.8 Trial Pits**

Trial pits shall be of minimum 3 m. x 3 m. size at base so as to permit easy access for a visual examination of the walls of the pit and to facilitate sampling and in-situ testing operations. Precautions shall be taken to ensure the stability of pit wall, if necessary even by the provision of shoring. Arrangements shall be made for dewatering if the pit is extended below water table. In-situ tests shall be conducted and undisturbed samples obtained immediately on reaching the specified depths, so as to avoid substantial moisture changes in the subsoil.

After completion of tests and examination, the pits shall be suitably backfilled as directed by the Engineer. Unless specified otherwise, the excavated soil shall be used for this purpose.

**9.5.1.9 Standard Penetration Test (SPT)**

The equipment and procedure for Standard Penetration Test shall conform to IS:2131. The bottom of bore hole shall be cleaned of mud slurry before conducting the Standard Penetration Test (SPT). The SPT shall be conducted generally at 1.5 m intervals and at changes of soil strata, as per IS:2131. The blow count shall be recorded. If the blow count exceeds 75 or if the penetration is less than 25 mm per 50 blows, the test shall be stopped.

**9.5.1.10 Static Cone Penetration Test**

The test equipment and procedure shall meet the requirements of IS:4968 (Part III). This test shall not be carried out on gravelly soils and for soils having SPT value greater than 50. The capacity of the equipment to be used for test shall not be less than 3.0 tonnes but preferably 10.0 tonnes. The cone resistance and cone & friction resistance shall be measured at pre-determined intervals. The rate of pushing shall be 1 cm per second. Unless otherwise specified it shall be conducted upto a depth of 25 m. If the penetration is found to be difficult at a shallower depth due to occurrence of fragment of rock or boulder the test shall be terminated and be executed at adjacent location as directed by the Engineer.

The results shall be prescribed in graphical form as well as in tabular form as given in Appendix-A of IS:4968 (Part III).

The Contractor shall carefully interpret the results of boring and sounding.

**9.5.1.11 Dynamic Cone Penetration Test**

The test equipment and procedure shall meet the requirement of IS:4968 (Part II). The driving shall not be done for more than 30 cm at a time after which it shall be stopped for a minute or two. Pumping shall, however, be continued. The tests shall be terminated when the blow counts exceed 35 for 100 mm. penetration when the cone is dry and 20 for 100 mm. penetration when the cone is penetrated by circulating slurry.

The results shall be reported in a suitable tabular form giving below counts for every 30 cm. penetration supplemented by a graphical plot of blow count versus depth.

#### 9.5.1.12 Plate Load Test

Plate load tests shall be conducted at the specified founding depth by making test pit of sufficient size as per IS: 1888. Side protection, if required, shall also be provided by the Contractor at no extra cost. The Contractor shall provide suitable access to the bottom of the pit. The load shall be applied to the plate by hydraulic jack of suitable capacity jacking against a fixed platform loaded with sand bags or heavy truss anchored in the ground. The increment of each loading shall be such that the ultimate load is reached in not less than ten increments. The water table level shall be noted in the nearest bore hole at the time of testing. If water table is within test zone to a depth of 3 times the width of plate, it is advisable to conduct the test at higher level.

The pit shall be backfilled with excavated earth in layers not exceeding 300 mm and well compacted.

#### 9.5.1.13 Cyclic Plate Load Tests

The equipment and set up for cyclic plate test shall be similar to plate load test described above. The testing procedure shall be as per IS: 5249. The duration of each loading and unloading cycle shall be decided based on the type of soil under investigation. The initial loading and unloading cycles upto the safe bearing capacity of soil should be with smaller increments in load. The magnitude of load increment should be such that the ultimate load is reached in five to six increments. Based on the above test, the Contractor shall recommend the coefficient of sub-grade reaction, coefficient of elastic uniform compression.

#### 9.5.1.14 Vane Shear Test

The test shall be conducted in soft to firm clays and sensitive clays. The test shall also be conducted in case of stiff fissured clays where samples cannot be taken. Tests may also be conducted by direct penetration from ground surface. The equipment used for vane shear tests shall be as per IS : 4434.

Straightness of vane shall be checked while the entire assembly of vane connected with the rod is being lowered to the bottom of bore holes. Samples shall be collected from the levels at which the tests have been conducted.

The results shall be reported in a suitable tabular form.

#### 9.5.1.15 In-Situ Permeability

In-situ permeability test shall be performed in the bore holes specified or as directed by the Engineer for the determination of the permeability coefficient of the soil. The tests shall be conducted as per IS : 5529 (Part I) using pumping out method with piezometer installations.

#### 9.5.1.16 Menard Pressure Meter Test

This test shall be carried out as per IS : 1892 to the full depth of bore holes, to assess the coefficient of earth pressure at rest and the stress-strain modules of soil. The tests shall be carried out at every 3.0 m. intervals.

The Contractor shall submit, for approval of the Engineer, detailed arrangement drawings for the tests including the detail of the equipment proposed.

**9.5.1.17 Block Vibration Test**

In-situ dynamic properties of the soil shall be determined by performing Block vibration tests in accordance with IS:5249 at the location and depth indicated. A plain concrete block in concrete grade M 15 and of size 1500 x 750 x 700 mm shall be cast, at the specified founding depth for machine foundations. The test pit should be of suitable size having sufficient clearance for conducting the test. Forced vibration and free vibration tests shall be conducted. The wave propagation test for determination of shear modules shall also be conducted by exciting the block to the steady state vibrations in the vertical direction. The block shall have suitable provisions to fix the oscillator in different modes and at different frequencies. By suitable and adequate instrumentation, the soil responses to the excitation are measured and various dynamic properties are computed. Based on these tests, the Contractor shall recommend design values to be adopted in design. Before backfilling the pit, the concrete block shall be dismantled and disintegrated and all rubbish shall be disposed off as directed by the Engineer.

**9.5.1.18 Electrical Resistivity**

Electrical Resistivity of subsurface layers shall be determined by vertical electrical soundings by Wenner's method as indicated in IS:1892. The spacing between the electrodes is initially kept as 0.5 metres and then gradually increased in steps of 0.5 metres upto 5.0 metres depth. Graphical representation of resistivity versus depth shall be plotted.

**9.5.1.19 Laboratory Tests**

All laboratory tests to assess the engineering properties of soil/rock shall be conducted by the Contractor in an approved laboratory. It is not the intent nor is it practical to specify all technical details and requirements of soil testing in the laboratory that would enable the proper evaluation of the soil parameters used in the detailed engineering stage. The Engineer reserves the right to direct the Contractor to perform any particular test during the course of the investigation. The Contractor shall keep furnishing preliminary copies of all test results to the Owner and the Engineer for their review.

**9.5.1.20 Soil Report**

The soil report shall include but not limited to the following.

- A detailed write up on the procedures adopted in all phases of the soil investigation.
- A plan of bore hole and field test locations.
- Individual bore logs indicating various soil strata encountered, their thicknesses and classifications, sampling locations, ground level, laboratory test results, SPT blow counts, ground water level and pertinent data.
- Cross section of soil profile in two perpendicular and diagonal directions and all load test curves & consolidation test curves.
- Detailed test results, laboratory observations both in tabular and graphical form and necessary extracts from technical literature used in calculation, evaluation & recommendations.
- Recommendation for type, depth, ultimate and safe bearing pressure and settlement of foundations for various structures.
- A summary of all design parameters.

The Contractor's recommendations shall include specific and definitive information on the following, supported by detailed calculations.

- a. Founding depths for various foundations as given below and corresponding safe soil bearing capacities evaluated from both strength and settlement considerations. Values obtained from field tests and laboratory tests shall be compared and suitable interpretation shall be furnished.
- i) Heavy foundations for powerhouse building columns, boilers.
  - ii) Heavy machine foundations such Turbo generator foundation, FD fan etc.
  - iii) Foundations for smaller and larger circular storage tanks.
  - iv) Light foundations for non plant buildings, sheds, compound wall, small pumps etc.
- b. Consolidation and settlement characteristics.
- c. Coefficient of subgrade reaction.
- d. Dynamic properties of soil.
- e. Type and capacity (vertical and lateral) of piles, if necessary, and data/ information on related aspects.
- f. Anticipated problems during foundation construction and recommended solutions.
- g. Roads, paving and grade slabs.
- h. Harmful chemical contents in soil and ground water, if any, and recommendations to protect underground structures from their harmful effects.
- i. Coefficient of earth pressure to be adopted for design of retaining structure.
- k. Specification for soil to be used for backfilling.
- l. Swelling characteristic of soil clearly indicating all swelling pressure etc.

### 9.5.2 Earthwork in Site Grading & Embankment

#### 9.5.2.1 Scope

This specification covers the requirement in respect of materials, workmanship and quality for clearing, grubbing, grading, forming embankments and compacting of the areas in all kinds of soil.

#### 9.5.2.2 Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

- |          |   |
|----------|---|
| IS:2720  | Method of test for soils - grain size (Part 4) analysis   |
| IS:2720  | Method of test for soils - Determination (Part 5) of limit & plastic limit  |
| IS:2720  | Method of test for soils - Determination (Part VII) of water content - dry density relation using light compaction. |
| IS:10379 | Code of practice for field control of moisture and compaction of soils for embankment and sub grade.                |

#### 9.5.2.3 Materials

Earth used for filling shall be selected earth as approved by the Engineer and free from organic and other objectionable matter. As far as possible excavated earth from excavation for foundations within the project area shall be used for filling. All clods of earth shall be broken or removed. Expansive soil shall not be used. The Contractor shall indicate in his offer the location of borrow areas and type of soil that he proposes to use.

Soil having plasticity index less than 20 and maximum proctor laboratory dry density more than 1.5 gm/cc shall only be used.

Adequate dewatering facilities like dewatering pumps, pipes etc. shall also be provided by the Contractor for this work including for excavation in borrow areas at his own cost.

#### 9.5.2.4 Initial Levels

The Contractor shall carry out the survey of the site before starting any work by taking accurate cross-section of the areas perpendicular to established grid / reference lines at 10 m interval or other intervals chosen by the Engineer based on the ground profile. For embankments initial levels shall be taken along the line of embankment and at right angles to the proposed alignment. These shall be checked by the Engineer and thereafter properly recorded.

#### 9.5.2.5 Clearing

The area to be graded shall be cleared of plants, logs, stumps, bush vegetation, rubbish slush etc. If any roots of stumps of trees are met they shall also be removed. The material so removed shall be disposed of as directed by the Engineer including burning if necessary. Trees to be cut shall be marked and the Engineer's approval taken before felling them. After the tree is cut and roots taken out the pot holes formed shall be filled with good earth in 250 mm layers and compacted. The tree shall be cut in suitable pieces as instructed by the Engineer, stacked and delivered to the Owner. After the area is cleared of plants, logs, vegetation etc., the filling area shall be compacted with power roller of 8 - 10 tonne capacity to obtain 90% of maximum proctor laboratory dry density of top soil as per IS:2720 part VII, Initial level shall be taken again as described in the above clause. These initial levels shall be considered for calculation of compacted volume of fill subsequently.

#### 9.5.2.6 Grading

The grading shall be carried out so as to obtain the levels indicated in the drawing after compaction. Generally such grading includes cutting and filling. The Contractor may employ any suitable means, mechanical, manual or a combination of both. The filled up area shall normally be filled with selected earth in layers of 250 mm (in loose condition uncompacted thickness) and compacted using rollers so as to obtain a density desired by the Engineer, normally minimum of 95 % of Proctor dry density for cohesive soils and 85% of Relative Density for non-cohesive soils.

When a layer of loose earth over an area has been removed during grading, the area shall be prepared by ploughing to loosen the earth before addition of soil to make up the lost earth. After the addition of soil over the ploughed area, it shall be compacted to the desired density.

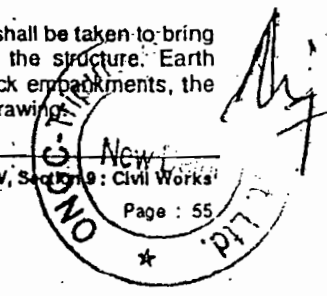
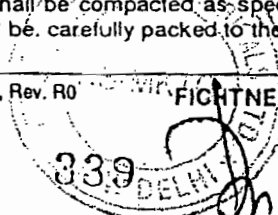
#### 9.5.2.7 Embankments

The finished formation width, side slopes and grade of the embankment shall be true to the line and level as shown on the drawings.

The embankment shall be made up in layers not exceeding 250 mm thickness (uncompacted thickness), over the whole width between the surface of the side slopes and shall be slightly concave in section so as to retain the water for water subsidence. All large clods shall be broken up.

When the embankments are on side-long ground the whole area of the embankment on slope shall be benched out or stepped so as to prevent the material from slipping.

In construction of embankment over the culverts or pipe drains care shall be taken to bring the embankment up equally on both sides and over the top of the structure. Earth embankment shall be compacted as specified under Grading. In rock embankments, the rock filling shall be carefully packed to the depths as shown on the drawing.



If embankments are made from borrow pits, the Contractor shall excavate the earth from borrow pits at the locations indicated on the drawings. They shall be regular in width and shape and shall be properly graded, drained and finished with neatly trimmed slopes.

#### 9.5.2.8 Testing and Acceptance Criteria

The degree of compaction shall be as specified above or as decided by the Engineer as per site conditions. The actual method for measuring the compaction will be decided by the Engineer. The Contractor shall carry out at his own cost the required tests to prove that the soil has been compacted to the desired dry density. These tests shall be carried out at different stages of filling and also after entire fill height has been completed. Since the degree of compaction largely depends on moisture content of soil, a close watch shall be kept on it and corrections done to optimise the moisture content. Generally the moisture content shall be brought to within plus or minus 2% of optimum moisture content prior to rolling. The quality control operations shall include but not limited to the following items of work.

- i) Lines, levels and grades
  - a) Periodic surveys
  - b) Establishment of markers, boards etc.
- ii) Grading
  - a) Checking the quality of fill material
  - b) Checking moisture content of fill material
  - c) Checking degree of compaction

The Contractor has to offer inspection request on each layer and Engineer may take the inspection on degree of compaction if desires. If a layer fails to meet the required density, it shall be reworked or the material shall be replaced and method of compaction/equipment altered as directed by the Engineer to obtain the desired density.

#### 9.5.3 Concrete Piling

##### 9.5.3.1 Scope

This specification covers the requirement in respect of materials, installation and testing of driven cast-in-situ, bored cast-in-situ, driven precast and bored precast concrete piles.

##### 9.5.3.2 Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions (with all official amendments) as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

- IS:2131 Method of standard penetration for soils  
IS:2911 Code of practice for design and construction of pile foundation.

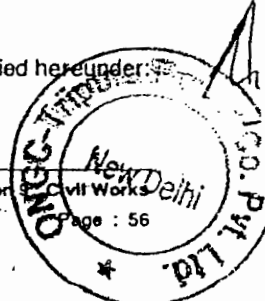
##### 9.5.3.3 Materials

The materials, cement, aggregates, steel used in the work shall be as specified hereunder:



FICHTNER India

Part IV, Section



**Cement** Ordinary Portland cement (43 Grade) conforming to IS:8112 shall be used for superstructure and Portland Slag Cement conforming to IS 455 (Refer Note 7 of Clause 8.2.4.2 of IS:456-2000) for substructures, which shall be decided based on the final Soil Investigation Report

Aggregate Machine crushed blue granite conforming to IS:383.

**Steel** High yield strength deformed bars conforming to IS 1786 shall be used for reinforcement. In view of the corrosive atmosphere, rebars with corrosion resistance without compromising bondage between steel and concrete such as TISCON CRS or SAIL TMT HCRM shall be adopted.

**Water** Water used for mixing shall be potable water conforming to IS:456.

#### 9.5.3.4 Requirements for Precast Piles

Precast piles shall be of octagonal shape, unless otherwise specified or approved by the Engineer.

The casting yard shall be so arranged that piles can be lifted directly from their beds and transported to the installation point with a minimum of handling.

Piles shall be cast in one operation. The form boxes shall be robust and clean using horizontal steel shutters of suitable length. The concrete shall be vibrated with the aid of shutter/immersion vibrators. Care shall be exercised that no cement slurry is lost. All faces of the piles shall be worked to be as smooth and dense as possible, including the exposed face at the top.

The cross-sectional dimensions of the pile as cast shall not be less than the specified dimensions and shall not exceed them by more than 6 mm. Further, any face of the pile shall not deviate by more than 6 mm from a straight edge 3 m long, laid on the face. The centroid of any cross-section of the pile shall not deviate by more than 12 mm from the straight line connecting the centroids of the end faces (head and tip) of the pile, or 1/500 of pile length, whichever is the least.

Side shutters shall not be struck till after 24 hours from the time of casting or later if so instructed by the Engineer.

Piles shall not be moved from the beds on which they were cast until the concrete has sufficiently hardened. This period shall be a minimum of 10 days for ordinary Portland cement/Sulphate resistant Cement concrete and 7 days for rapid hardening Portland cement concrete from the time of casting. Care shall be exercised by the Contractor during such movement that the pile does not crack or chip.

Piles shall be kept continuously wet for ten days from the time of casting, but longer curing shall be done, as directed by Engineer, when hard driving is expected.

When piles are stacked between the period of wet curing and driving/Installing, they shall be protected from rapid drying by sheltering them from the wind and direct sunlight by covering the stacks.

All care shall be taken at all stages of transporting, lifting and handling of the piles to ensure that they are not damaged or cracked. During transport, the piles shall be supported at the appropriate lifting hooks provided for the purpose. If the piles are put down temporarily after being lifted, they shall be placed on trestles or blocks located at the lifting points.

Piles shall be provided with a coaxial cast iron or steel shoe for protecting the tip of the pile during driving, as indicated on drawing. The area of the tip of the shoe shall be such that the stress in the concrete in this part of the pile is within the safe limits.

For precast piles to be installed in pre-bored holes, a grouting pipe of appropriate diameter shall be embedded along the centre line of the pile for the entire length.

#### 9.5.3.5 Requirements for Driven Piles

Standard helmet of cast-steel or structural steel shall be litted on the pile head, unless a follower is required, to ensure axial alignment of the hammer and pile at instant of impact. Short hardwood dolly in one piece not thicker than the width of the pile with grains parallel to the pile axis shall be used with the helmet and shall be closely fitted inside the recess on top of the helmet. A steel band is to be pressed over the top of the dolly to prevent it from splitting. A steel plate of 25 mm minimum thickness shall be used on top of the dolly to distribute the hammer blows. The use of wood chips, small wood blocks or such other materials is prohibited. The Contractor shall note on the driving log when fresh cap block material is placed under the hammer and shall discount the measured resistance to driving immediately thereafter.

It is desirable that double acting diesel/ compressed air/steam operated hammers are used for driving the pile. Single acting hammers may be used only if permitted by the Engineer. The Bidder shall submit with his Bid, the details of driving equipment to be specifically deployed on this job. It shall be the responsibility of the Contractor to use the right equipment for driving. The Contractor shall satisfy the Engineer regarding suitability, efficiency and energy of driving equipment. The hammer blows shall always be in line with the pile axis. Drop of each and every blow shall be controlled and monitored.

The heaviest practical hammer with drop or stroke limited to the minimum shall be employed so as not to damage the pile. In any case, the weight of the hammer shall exceed 10 times the weight of 1.0 M length of the pile. Long continued driving after the pile has almost ceased to penetrate, shall be avoided. Care shall be taken not to damage the piles by overdriving. Any sudden change in the rate of penetration, which cannot be ascribed to the nature of the ground shall be noted and its cause ascertained, if possible, before driving is continued/pile is accepted.

The Contractor under the supervision of the Owner/Engineer shall take temporary compression or reboundset curves on the piles during driving, as described in IS-2911. These shall be taken at a few pile penetration depths and at the final set, on the first few piles of each size and/or length. The values of (C1 + C2 + C3) thus obtained shall be used to recheck and modify if necessary the required "Set" for the safe load bearing capacity specified for the pile.

The final set of each pile shall be recorded as the penetration in millimeters per 10 blows.

Set criterion shall be mutually agreed upon on the basis of set recorded for piles for initial pile load tests, the Contractor's pile driving equipment, etc. In case of any conflict or disagreement, decision of the Engineer shall be binding.

#### 9.5.3.6 Installation Of Piles

##### General

##### Location of Piles

A plan in triplicate showing clearly the designation of piles to be installed by an identifying system shall be submitted to the Engineer before the installation of piling is started.

- Trial bore holes

To ascertain the founding strata, especially for precast driven piles, trial bore holes shall be carried out.

- Record of Piles

The record shall be kept by the contractor in an approved form of the total penetration of every pile and the behaviour of each pile during driving / boring. Type of soil encountered, depth of boring/driving, depth of water table, cut-off level working level, time taken for concreting, consumption of cement, density of bentonite slurry and all other important observation shall be indicated in the standard record format. Any deviation from the designated location, alignment or load carrying capacity or any upheaval noticed only any pile during installation shall be immediately reported to the Engineer and adequate corrective measures taken as decided by the Engineer. On the completion of pile installation, pile driving / boring records together with the records of such changes or other sub-surface information that were obtained during the installation of piles shall also be submitted by the Contractor with the Engineer in triplicate.

#### Sequence of Installation

The Engineer shall decide the sequence of the group of piles that the Contractor should undertake for installation and Contractor shall proceed from those in the centre of the group towards those on the periphery or from one side to other.

#### Installation

- General

Piles shall be installed with due consideration for safety of adjacent structures, working equipment etc by a method which leaves their strength unimpaired & which develops and retains the required load bearing capacity.

- Driven cast-in-situ piles

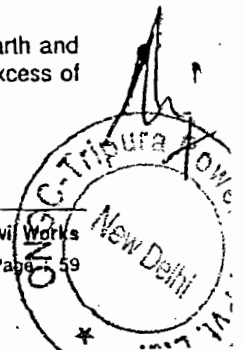
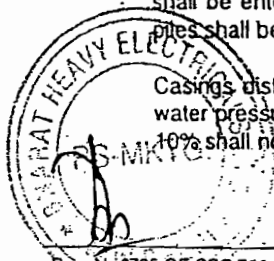
Steel casings, shall be straight and shall have sufficient wall thickness and strength to withstand without damage, distortion etc., the handling stresses and driving stresses set up in obtaining the specified depth and set and to resist harmful distortion or buckling due to soil pressures developed during installation of pile or adjacent piles. Joints shall be welded or lockseamed. Casings and their joints shall be sufficiently tight to exclude water.

Casings shall be of such diameter as to give the specified nominal diameter of the pile. Casing lengths shall be the maximum consistent with standard practice, transport, handling and driving facilities.

Detachable shoes shall be of cast iron or mild steel and of requisite strength of the standard sizes used with the respective steel casings and the shoe shall be coaxial with the steel casing.

In case of piles close to the existing plant & structures, the Engineer if necessary, may specify the fall of smaller than the standard and working hours for the rig & no extra claim shall be entertained due to these restrictions. The equipment and methods for installing piles shall be such that the loss of energy is limited to a suitable minimum.

Casings distorted from true and uniform shape, whether caused by driving or earth and water pressure, resulting in a reduction of the cross-sectional area of the pile in excess of 10% shall not be used on the work.



If there is a major variation between the depths at which adjacent foundation piles in a group meet refusal, a boring shall be made nearby to ascertain the cause of this difference. If the boring shows that the soil contains pockets of highly compressible material below the level of shorter pile, the pile shall be taken below the bottom of such layer.

Provisions of IS:2911 (Part 1/Sec.1) shall be adopted for requirements not covered above.

- Bored cast-in-situ piles

Bored cast-in-situ piles shall be installed by suitable choice of techniques covering the manner of soil-stabilisation i.e the use of casing and / or use of drilling mud, manner of concreting i.e direct pouring and placing or by use of tremie and choice of boring tools in order to permit a satisfactory installation of pile. Preferably Direct Mud Circulation method shall be adopted for installation. The bentonite and bentonite slurry shall meet the requirement specified in IS. A minimum length of 1-meter of temporary casing shall be inserted in each bored pile. In case of collapsible soil strata, the full depth of boring shall be provided with temporary casing. If piles are founded on a rocky strata, the casing shall be keyed for a minimum depth of 150 mm. After the borehole has been drilled to its final depth, fresh bentonite slurry shall be pumped through the chisel resting at the base of hole, to remove completely all cuttings and other loose materials from the base of pile. During this flushing the speed of pump shall be increased to maintain additional high pressure for 10 - 15 minutes. After the hole has been thoroughly flushed, the chisel and API rods shall be removed for the concrete. When installing piles in a group, sufficient time shall be allowed for freshly poured concrete in the adjacent pile to set.

Provisions of IS:2911 (Part 1/Sec.2) shall be adopted for requirements not covered above.

- Driven Precast Piles

A minimum period of 28 days shall be allowed for curing from the time of casting the pile, before selecting the pile for driving. This period may be relaxed by the Owner/Engineer if he is satisfied that the pile has achieved adequate strength to take up driving stresses without suffering distress. In such case the Contractor shall obtain expressed permission of the Owner/Engineer in writing.

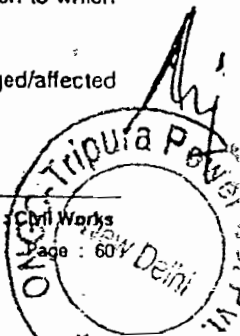
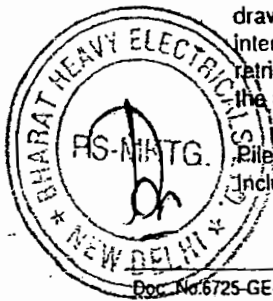
Driving shall be performed with fixed leads or leaders capable of holding the pile firmly in position, with the hammer and the pile in axial alignment. Care shall be taken during driving to prevent and correct any tendency of the pile to twist or rotate. Pile drivers shall have firmly supported leads extending down to the lowest point the hammer must reach.

Where cut off levels are below grade level, the Contractor shall be required to use followers to drive the pile further below ground level when the head of the pile is near ground level.

In general, driving sequence of piles and clusters of piles shall, unless otherwise specified by the Engineer, proceed from the centre of the pile groups and progress outward from the centre, towards any two opposing sides of the perimeter.

Piles shall be driven in a continuous manner, without interruption, until the pile has been driven to final elevation of specified resistance, or a combination of both as shown on the drawings or as directed by the Owner/Engineer. Where, in exceptional cases driving is interrupted before final penetration is reached, the set per blow immediately upon retrieving shall be disregarded and such pile shall be driven to the final elevation to which the adjacent piles, which were not interrupted, have been driven.

Piles shall be driven in such manner that previously driven piles are not damaged/affected including partly set concrete of lengthened piles.



Piles shall not be abandoned partially driven at the end of the shift.

When a pile head is damaged during driving, the head shall be cut-off square at sound-concrete level, and all loose particles shall be removed by wire brushing, followed by washing with water. If pile is subjected to further driving, the head shall be replaced by concrete of an approved grade. Such piles shall not be driven until approved concrete has reached the specified strength.

If the driving of the pile has been accepted but sound concrete of the pile is below the cut off level, the pile shall be made good to the cut-off level with concrete of a grade not inferior to that of the concrete of the pile. While lengthening the pile, joints in the reinforcement shall be such that the full strength of the bar is effective across the joint. Welded joints shall be made in accordance with IS:816 and/or IS:1323 and the main longitudinal reinforcing bars in the head of the pile shall be exposed for at least 300 mm below the weld. For lap or splice joints sufficient link bars shall be provided to resist eccentric forces.

Provisions of IS:2911 (Part 1/Sec.3) shall be adopted for requirements not covered above.

- **Bored Precast Piles (Precast Pile Installed in Prebored Hole)**

Boring shall be similar to that for bored cast-in-situ piles.

Where indicated by site conditions, precast piles in prebored holes shall be socketed into competent stratum as indicated on the drawing or as directed by the Engineer.

In order to determine the competency of the stratum including rock for socketing as well as supporting the pile, standard penetration tests (SPT) shall be conducted during the progress of boring/chiselling into the stratum including rock.

The precast pile shall be brought near the borehole and lifted in vertical position. The pile shall be suspended over the borehole. The flush water shall be switched on through the central grout passage in the pile as the pile tip approaches the founding strata. On reaching the founding strata, water flush shall be continued for 10-15 minutes. Flushing shall be done under adequate pressure in order to ensure the cleaning of borehole bottom of any soft/cohesive material.

After cleaning the bottom of borehole, cement/sand grout (1 cement : 2 sand) with W/C ratio of 0.55 shall be pumped through the grouting pipe in the pile so as to grout the base and fill up the annular space around the pile. The grouting pressure shall be adequate to grout the full length of the pile. The minimum thickness of the grout mantle shall be 40 mm.

Temporary liners/casings if provided, shall be extracted progressively as the grout level inside the borehole rises.

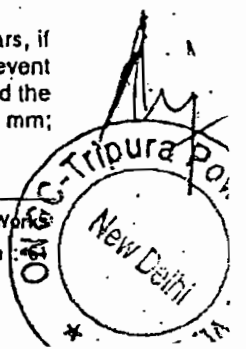
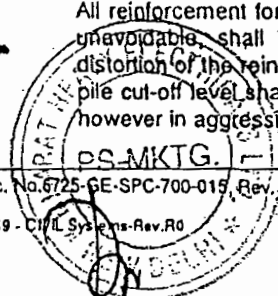
Provisions of IS:2911 (Part 1/Sec.4) shall be adopted for requirements not covered above.

**Jetting of Piles**

Jetting of piles by means of water shall not be permitted.

**Reinforcement**

All reinforcement for use in pile shaft shall be assembled and joints in longitudinal bars, if unavoidable, shall be made by lapping and the lap shall be tack-welded to prevent distortion of the reinforcing cage. The projecting length of the longitudinal bars beyond the pile cut-off level shall be equal to 50 times bar diameter. Minimum cover shall be 50 mm; however in aggressive soil cover shall be increased to 60 mm.



The helical reinforcement shall fit tight against the longitudinal bars and be fixed to them by soft annealed 16 gauge black iron wire, the free ends of which shall be turned into the interior of the pile.

In addition, lateral circular reinforcement shall be provided at spacing approved by the Engineer and longitudinal bars shall be welded to templates. Care shall be taken to preserve the correct cover and alignment of reinforcement free from any twist, throughout the operation of placing the reinforcing cage into the borehole and concreting of pile.

#### Concreting work in cast-in-situ piles

The specifications laid down for concrete work shall also apply to the concrete work for piles, except as modified in this specification. The Contractor shall submit mix design as per IS method or ACI Code 211.1 and carry out adequate number of tests to ensure the minimum strength. The minimum cement content and the maximum water cement ratio considered in mix design shall be 400 kg/m<sup>3</sup> and 0.45 respectively unless otherwise specified. The slump (130 - 180 mm flowing consistency for bored piles, 80-100 mm flowing consistency for driven piles) shall be selected by the Contractor based on the suitability of the chosen method of concreting for pile installation. If, during execution, workability is to be increased, higher cement content or admixtures shall be used with Engineer's approval.

The concrete shall be freshly mixed and of sufficient quantity in the casing (where used) to ensure that during the withdrawal of the casing, a sufficient head of concrete is maintained to prevent inflow of subsoil and ground water and to prevent formation of necking or wasting.

Exposed portions of piles be cured for ten (10) days.

When installing piles in a group, sufficient time shall be allowed for the freshly poured concrete in a pile to set before installing adjacent piles.

All care shall be taken to prevent formation of voids in the pile by pockets of air trapped within. Particular attention shall be paid to this during withdrawal of casing. The volume of concrete placed shall be checked against calculated volume of pile at the time of withdrawal of casing.

#### Minimum Casting Levels

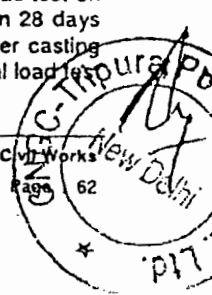
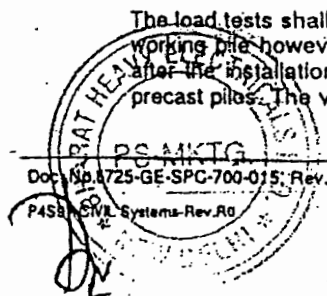
Piles shall be cast atleast 500 mm above the finished cut-off level so as to permit the removal of all laticence and weak concrete.

#### 9.5.3.7 Testing of Piles

##### General

The Contractor shall cast/drive test piles for each kind of loading and carry out the load bearing tests before actually commencing the work unless otherwise specified, the number of test piles shall be based on the criteria specified in IS:2911 (Part 4). The Contractor may be allowed to use quick setting cement or add the necessary admixtures to enable him to conduct the test within seven (7) days after installation for cast-in-situ piles or within 7 days of casting for precast piles.

The load tests shall be carried out by the Contractor as described herein. The load test on working pile however shall not normally be undertaken by the Contractor within 28 days after the installation of the pile in position for cast-in-situ piles or 28 days after casting precast piles. The vertical load test shall be carried out on single pile. The lateral load test



shall be carried out between two piles. Before any load test is made the proposed arrangement for carrying out the load test including the preparation of the structure to receive the loads and the type of loading to be adopted shall be furnished by the Contractor and approved by the Engineer. The load tests shall be made under the supervision of the Engineer. The complete record of such loads shall be filed with the Engineer in triplicate. The responsibility for carrying out such load tests satisfactorily and safely and on proper lines rests with the Contractor.

The test shall be carried out at cut-off level wherever practicable, otherwise suitable allowance shall be made in the interpretation of the test results.

#### Method of Testing

The testing shall be conducted according to IS:2911, Part IV as described herein. If there is any discrepancy observed between the IS guidelines and the specification given here, the following guidelines shall be governing.

##### - Vertical load test (compression)

The test load to be applied on the loading platform supported on pile shall be

- a) 2.5 times the proposed safe designed load in case of test pile.
- b) 1.5 times the proposed safe designed load or upto a maximum settlement of 25 mm whichever occurs earlier in case of working pile.

The load increments shall be

- a) 1/5, 2/5, 3/5, 4/5, 1, 1.25, 1.5, 1.75, 2, 2.25 and 2.5 times the safe designed load in case of test pile and
- b) 1/5, 2/5, 3/5, 4/5, 1, 1.25 & 1.5 times the safe designed load in case of working pile.

Readings of settlements shall be recorded with minimum 2 dial gauges of 0.01 mm sensitivity each positioned at equal distance around the pile and normally held by datum bars resting on immovable supports at a distance of 3D (subject to minimum of 1.5 m) from the edge of the pile where 'D' is the stem diameter of circular piles or diameter of circumscribing circle in the case of square or non circular piles.

Taking of measurement or displacement of the pile top for each load increment is continued until the settlement is either 0.1 mm in first 30 minutes or 0.2 mm in first one hour or till 2 hours whichever occurs first.

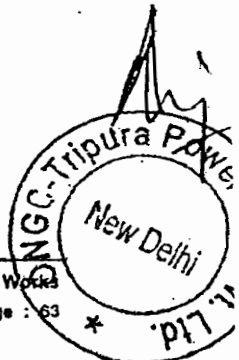
The final test load shall be maintained for 48 hours. The safe load on single pile for the test pile shall be at least of the following:

- a) Two thirds of the final load at which the total displacement attains a value of 12 mm.
- b) 50 percent of the final load at which the total displacement equal 10 % of the pile diameter in case of uniform diameter piles and 7.5 % of bulb diameter in case of under-reamed piles.

##### - Lateral Load Test on Pile

The safe lateral design load shall be the least of the following:

- i) 5% of the safe axial load.
- ii) Load corresponding to a maximum calculated deflection of 5 mm.



The test load shall be

- a) 2.5 times the proposed safe lateral design load or 12 mm whichever occurs later in case of test piles.
- b) 1.5 times the proposed safe lateral design load or 7.5 mm whichever occurs earlier in case of working pile.

The load increments shall be similar to the one given for the vertical load. The safe lateral load on a single pile shall be taken as the least of the following :

- a) Fifty percent of the final load at which the total displacement increases to 12 mm.
- b) Final load at which the total displacement corresponds to 5 mm.

- **Cyclic Load Test on Pile**

Alternate loading and unloading shall be carried out at each stage as given in relevant clause and each loading shall be maintained as given in relevant clause and each unloading stage shall be maintained for atleast 15 minutes and subsequent elastic rebound in the pile shall be measured accurately as specified in relevant clause. This test shall be continued upto 1.5 times the proposed safe design load. The skin friction and end bearing load of the pile shall be separated out either by graphical method or analytical method as described in IS.

- **Pull out Test**

Pullout test requirements shall be as per IS:2911 (Part 4).

**9.5.3.8 Acceptance Criteria**

The following are the general acceptance criteria.

The clauses pertaining to acceptance of concrete work as described for Plain and Reinforced Concrete work shall also be applicable to the work of piles.

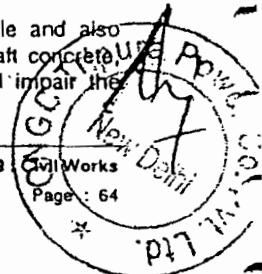
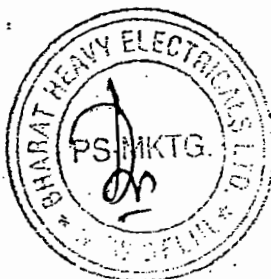
**Positional Tolerance**

The permissible positional deviation of pile should not be more than 75 mm or D/4 whichever is less where 'D' is the diameter of pile (75 mm or D/10 whichever is more in case of piles having diameter more than 600 mm) at the working level. In the case of single pile under a column the positional deviation should not be more than 50 mm or D/4 whichever is less (100 mm in case of piles having diameter more than 600 mm). This will be measured after the driving of the pile and during the inspection of the tube prior to placing of reinforcement and concrete. Should the deviation be greater than that specified above, the Contractor shall remove the casing at his own cost & redrive the pile, if ordered so by the Engineer.

In the alternative, the Engineer may at his discretion order the driving of additional piles at the Contractor's cost which he considers necessary after checking up the design load on the pile group.

**Pile size & capacity**

The Contractor shall guarantee 90% of full cross sectional area of the pile and also guarantee against occurrence of necking of wasting, bulging, spalling of shaft concrete, exposure of reinforcement, porous concrete and similar defects which will impair the



strength and durability of pile. The Engineer may direct the Contractor to completely exhume some or all test piles before or after load testing to examine the quality of the pile shaft. This shall be done either by excavating around the pile or by pulling out or by a combination of both methods. If the quality of the pile shaft does not satisfy the requirements of this specification and/or if the pile fails to attain workmanship or negligence on the part of the Contractor, all costs of mobilisation, installation and testing of test piles exhuming of test piles and any other work in connection with the test piles shall be to the cost of Contractor.

#### Structural Soundness

The concrete should have the minimum strength specified based on the cube test. The acceptance criteria mentioned in the specification for concrete works under 9.4.5 shall be referred in this aspect. However the Engineer reserves the right of rejecting any pile which in his opinion is not structurally sound or is not in proper position and alignment. The Contractor shall be bound to pull the same out and re-install a new pile in its place or leave the defective pile and instal at the Contractor's cost one or more additional piles to substitute the defective pile, as per directions of the Engineer.

#### 9.5.4 Earthwork in Excavation & Backfilling

##### 9.5.4.1 Scope

This specification covers the requirement of site clearing, excavation & backfilling in all types of soil for foundations, basements, trenches, drains, culverts etc.

##### 9.5.4.2 Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

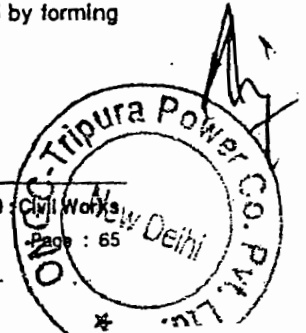
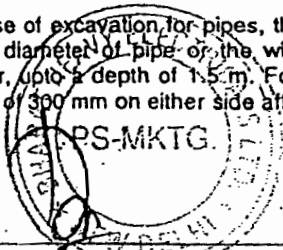
- IS:1498 Classification and identification of soils for general engineering purposes.
- IS:3764 Safety code for excavation works
- IS:4081 Safety code for blasting and related drilling operations
- IS:9759 Guidelines for dewatering during construction

##### 9.5.4.3 Setting Out

The work shall be set out to exact dimensions as shown on the drawings and shall be checked and approved by the Engineer before commencement of excavation.

In firm soil, the sides of excavation in foundations shall be kept vertical up to a depth of 1.5 m from the bottom and for greater depths the sides shall be widened by forming steps of 300 mm on either sides after every 1.5m from the bottom. Where soil is soft, loose or slushy, the width of steps shall be suitably increased or the side sloped or shored up, as directed by the Engineer. Working space shall be approved by the Engineer.

In case of excavation for pipes, the authorized width of excavation shall be 600 mm plus outer diameter of pipe or the width of bedding as shown in the drawing whichever is higher, upto a depth of 1.5 m. For higher depths, the width shall be widened by forming steps of 300 mm on either side after every 1.5 m from the bottom.



**9.5.4.4 Initial Levels**

Initial levels either in a definite grid pattern or as directed by the Engineer shall be taken by the Contractor jointly with the Engineer over the original ground prior to starting actual excavation work and after setting out.

**9.5.4.5 Clearing and Grubbing Etc.**

The area to be excavated shall be cleared out of trees, logs, stumps, bush, vegetation, rubbish, slush etc. and leveled up. Trees up to 300 mm girth shall be uprooted. Trees above 300 mm girth shall be cut up to 600 mm below ground level. Useful materials, saleable timber shall be the property of the Owner and hence shall be handed over. All the spoils and unserviceable materials and rubbish shall be burnt or removed from site to approved disposal areas as may be specified.

**9.5.4.6 Excavation and Cutting**

The Contractor shall excavate to remove materials of any nature or description which may be encountered and excavate to depths, widths and inclinations as shown on the drawings and/ or as directed. The bed of the excavation shall be made level and firm by watering and ramming. The Contractor shall not remove any tree without permission.

While carrying out excavation for drain work, the sides and bottom shall be cut to the exact shape, slope and gradient as shown on the drawings. The surface shall be properly dressed. Excavated material shall not be placed within 1.5 m from the edge of any excavation or half of trench depth whichever is more.

**9.5.4.7 Excavation in Rock**

Blasting where permitted shall be carried out as specified in IS:4081. Where blasting is prohibited, rock excavation shall be by chiseling, wedging or any other approved method. Depending on the exact location of rock excavation, decision to excavate by blasting or not will be taken by the Engineer.

**9.5.4.8 Variation In Excavation****Bad Soil**

Should the bottom of any excavation at design depth appear to be soft, unsound or unstable, the Contractor shall report the matter to the Engineer and if the Engineer so directs, shall excavate the same to indicated depths. The extra depth shall be filled up with concrete or such other materials as the Engineer shall direct. No extra compensation will be entertained in this account.

**Excavation Too Deep**

If the Contractor excavates to levels deeper than those shown on drawings for any reason other than those stated above, he shall fill it up at his own expense to the proper level with lean concrete 1:5:10 or sand filling as directed. No payment will be made for excavation taken down to depths more than those shown on the drawings or for the filling carried out as directed.

**Slips and Falls**

Every precaution shall be taken against slips and falls of earth, clay, sand or other materials in the excavations, but in the event of any such occurring; the Contractor shall at his own expense make good the space affected by slips or falls even if the affected area is outside the dimension of the work ordered.

The Engineer will determine in each case whether such affected area is to be filled up in whole or in part with concrete, brickwork or masonry of the quality used in the adjoining work or where only a part is to be so filled, the materials to be used for this remaining part.

If in the opinion of the Engineer there is a possibility of the newly constructed work having been damaged or disturbed by such collapse, the work shall be laid bare at the expense of the Contractor for inspection. Any damage caused shall be made good by the Contractor, at his own expense.

#### Soil/Sub-soil Water Condition

Boring and sub surface data regarding the nature of soil, sub-soil water furnished to the Contractor shall be taken as guidance only and variation there from shall not affect the terms of Contract. The Contractor must satisfy himself regarding the character and volume of all work under this item and expected surface, and/or sub-soil water to be encountered.

#### 9.5.4.9 Keeping Works Site Free From Water

The Contractor shall provide and operate pumps and all other equipment necessary to drain the sub-soil water, rain water etc. to the nearest sewer or drain through properly laid pipes or channels and keep excavation pits, trenches etc free from water at all times during excavation, backfilling and the continuance of the contract. Adequate care shall be taken to prevent movement of water through freshly laid concrete or masonry work. Sumps made for dewatering shall be kept clear of the foundation. Method of dewatering shall be approved by the Engineer but in no case the pumping arrangement shall be such that there is any movement of sub-soil or blowing-in due to differential head of water during pumping. If water table is high, well point dewatering has to be adopted for excavation beyond 1 metre below the water table. The dewatering shall be continued for a sufficient period so as not to affect the strength and other properties of the concrete. Guideline given in IS:9759 shall also be followed.

#### 9.5.4.10 Protection of Work

The Contractor shall support and maintain adjoining and abutting property and structures to render work safe to persons and property.

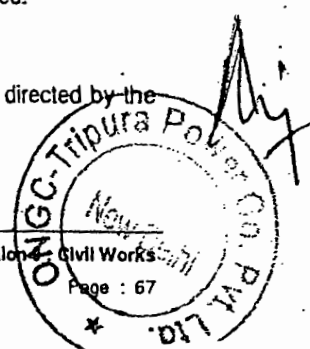
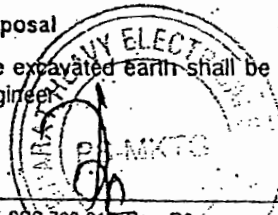
The Contractor shall provide necessary decking, guard, fencing, planking with red flags and red lights at night to maintain safe pedestrian and vehicular traffic near all open excavations.

#### 9.5.4.11 Shoring and Strutting

Shoring and strutting shall be used as directed when excavation is to be carried out in soft or slushy soil which is likely to collapse during the excavation of the work. The shoring shall be either open or close boarded type depending on the nature of the soil and depth of excavation and the type adopted shall be as directed by the Engineer. While excavating in very unstable ground requiring support throughout the period of excavation, runners shall be used and shall be driven always in advance of the excavation. The size and spacing of different members to be used in shoring shall be as directed by the Engineer, depending on the site conditions. If however slips do occur, the same shall be removed by him and backfilled later by him at his own expense. The withdrawal of shoring & shoring material shall be done very carefully to prevent the collapse of pit or trench. No claim shall be entertained for any material which cannot be removed and is lost or buried.

#### 9.5.4.12 Disposal

The excavated earth shall be disposed off in the following manner or as directed by the Engineer



- i) By keeping separately the materials suitable for backfilling/area filling and material not suitable at areas to be designated by the Engineer.
- ii) The excess material remaining after back-filling/area filling shall be spread evenly so as to allow natural flow of water in the area.

#### 9.5.4.13 Backfilling and Filling in Plinth

Earth used for filling shall be free from organic and other objectionable matter. As far as possible, materials obtained from excavation in foundation shall be used. The earth shall be basically CNS soil (Cohesive Non-Swelling Soil). All clods of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not bigger than 150 mm in size and mixed with fine materials consisting of decomposed rock, moorum or earth and the mixture shall be used for filling. Expansive soils shall not be used for filling. Maximum thickness of filling (uncompacted) shall be 200mm and compacted to 95% of proctor density.

##### Filling Around Foundation with Earth

Filling shall be carried out in layers not exceeding 200 mm (un compacted thickness) in depth. Each layer shall be watered, rammed and properly compacted to 95% of proctor density or 85% of relative density depending on the soil type. For Turbine Foundation it shall not be less than 98%.

##### Sand filling in plinth

Sand used for filling shall be free from dust, organic and other objectionable matter and shall not contain more than 10 percent of clay.

When filling has reached the appropriate level, the area shall be flooded with water for a minimum period of 24 hours to allow the fill to settle. The filling shall be allowed to dry and then compacted and dressed to the required level.

##### Filling in trenches for pipes

Filling in trenches for pipes shall be commenced as soon as the joints of pipes have been tested and passed. Filling of trenches shall be carried out simultaneously on both sides of pipes to avoid unequal pressure on the pipe. The earth shall be spread on the sides and top of the pipes in layers not exceeding 200 mm (un compacted thickness), watered, rammed and consolidated, taking care that no damage is caused to the pipe below. Maximum particle size for fill material around pipes shall be less than 20 mm.

#### 9.5.4.14 Testing and Acceptance Criteria

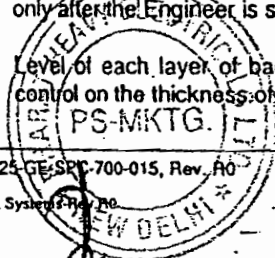
##### Excavation

On completion of excavation, the dimensions of the pits will be checked as per drawings after the pits are completely dewatered, the work will be accepted after all under-cuts are set right, all over excavations are filled with lean concrete or compacted earth as directed and all necessary shoring & strutting done, all temporary approaches to the bottom of trenches provided, all to the satisfaction of the Engineer.

##### Backfilling / Plinth Filling

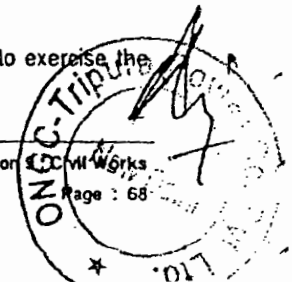
All filling shall be done to the compaction specified. The backfilling work will be accepted only after the Engineer is satisfied with the degree of compaction.

Level of each layer of backfilling shall be marked on the sides in order to exercise the control on the thickness of layer being laid.



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**9.5.5 Plain and Reinforced Concrete Work****9.5.5.1 Scope**

This specification covers the requirement in respect of materials, workmanship and quality for Plain Cement Concrete (PCC) and Reinforced Cement Concrete (RCC) for all types of structures in foundation and superstructure.

**9.5.5.2 Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

**Cement**

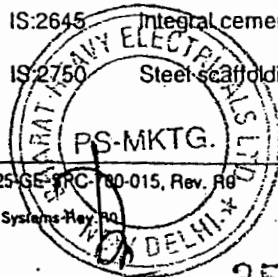
- IS:269 Ordinary and low heat Portland cement
- IS:455 Specification for Portland slag cement
- IS:1489 Specification for Portland pozzolana cement
- IS:4032 Method of chemical analysis of hydraulic cement
- IS:6452 High alumina cement for structural use
- IS:8041 Rapid hardening portland cement
- IS:8112 Specification for 43 grade ordinary Portland cement
- IS:12330 Sulphate resisting portland cement

**Aggregate**

- IS:383 Coarse and fine aggregates from natural sources for concrete
- IS:2386 Methods of test for aggregates for concrete
- IS:2430 Methods of sampling of aggregates for concrete

**Concrete Plain and Reinforced**

- IS:456 Code of practice for plain and reinforced concrete
- IS:460 Test sieves
- IS:516 Methods of test for strength of concrete
- IS:1199 Methods of sampling and analysis of concrete
- IS:1607 Methods for test sieving
- IS:1834 Hot applied sealing compounds for joints in concrete
- IS:2645 Integral cement water proofing compounds
- IS:2750 Steel scaffolding



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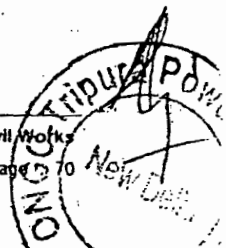
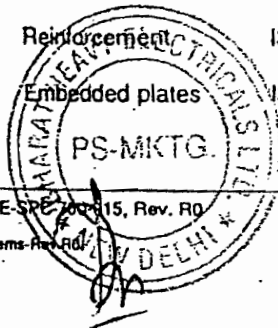


IS:2974	Code of practice for design and construction of machine foundations
IS:3370	Code of practice for concrete structures for the storage of liquids
IS:9013	Method of making, curing and determining compressive strength of accelerated-cured concrete test specimens
IS:9103	Admixtures for concrete
IS:9893	Precast concrete lintels and sills
IS:10262	Recommended guidelines for concrete mix design
IS:10297	Code of practice for design and construction of floors/roofs using pre-cast reinforced/pre-stressed concrete ribbed or cored slab units
IS:10566	Methods of tests for preformed fillers for expansion joints in concrete paving and structural construction
IS:10790	Methods of sampling of steel for prestressed and reinforced concrete
<b>Steel</b>	
IS:432	Mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement.
IS:1566	Hard-drawn steel wire fabric for concrete reinforcement
IS:1568	Wire cloth for general purposes
IS:1786	High strength deformed steel bars and wires for concrete reinforcement
IS:2502	Code of practice for bending and fixing of bars for concrete reinforcement
IS:2751	Code of practice for welding of mild steel plain and deformed bars used for reinforced concrete construction

**9.5.5.3 Materials**

All materials that shall be used for works covered under this specification shall conform to following standards / specification.

- Aggregate	Machine crushed blue granite conforming to IS:383
- Cement	IS:269 - Ordinary Portland Cement
	IS:455 - Specification for Portland slag cement
	IS:8041 - Rapid Hardening Portland Cement
	IS:8112 - High strength Ordinary Portland Cement
	IS:12330- Sulphate Resisting Portland Cement
- Reinforcement	IS:432/IS:1786/IS:1566
- Embedded plates	IS:2062



- Binding wire	16 SWG annealed iron wire
- Joint filler	Approved non extruding, resilient fillers
- Sand	River or pit sand conforming to IS:2116
- Water stops	PVC/Rubber/Metallic - GI, Aluminium, copper
- Admixtures	IS:9103
- Water	Clean, potable as specified in IS:456.

Source of coarse & fine aggregate shall be approved by the Engineer.

Test certificates for each consignment of cement procured have to be submitted by the Contractor to ensure conformity with relevant standards. The Engineer may reject such cements supplied in the event of unsatisfactory tests or in the event of deterioration due to age or bad storage etc. Decision of the Engineer shall be final in this regard.

Admixtures shall be used only after getting permission from the Engineer and as per the instruction of the manufacturer.

#### 9.5.5.4 Grades and Proportioning

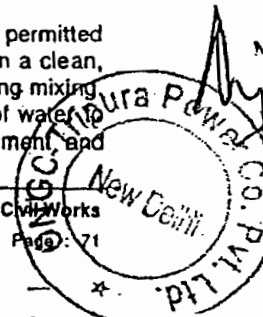
Any grades of concrete designated in latest revision of IS:456 as shown on the drawings or as specified shall be used. Design mix concrete shall be adopted for all RCC works. Contractor, at his own cost shall get this Design Mix done by any premiere institute like approved by the Owner. If the submitted results are not satisfactory to the owner, the Owner has every right to reject the design mix. In case the contractor fails to submit or comply with the design mix, he requires to follow Nominal Mix as per IS: 456 after obtaining the permission from Engineer. The mix shall be designed as per "Handbook on concrete mixes", SP:23. While designing the mix, the strength, durability, minimum cement content, maximum water cement ratio allowed and workability necessary for the job by most economical use of the various ingredients shall be considered by the Contractor. Contractor must use the same ingredients in the Design Mix which he uses in the works. The mix design shall be verified by carrying out preliminary test.

The water cement ratio, coarse aggregates and grading for each mix shall be predetermined from the results of cube tests of trial mixes. The mix proportions determined thus shall be followed at site and shall in no way relieve the Contractor of his responsibility as regards the prescribed strength mix. The mix proportions, however, shall be revised if the results of the cube tests during the construction show consistently lower than the prescribed one. No extra claim will be entertained due to such changes in mix designs, as the Contractor will be responsible to produce the concrete of required grade. The maximum size of aggregates used shall be as indicated in IS:456 or specified elsewhere.

Nominal mix concrete in accordance with IS:456 for grade M20 or lower may 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.

#### 9.5.5.5 Mixing

Mixing should be carried out in mechanical mixers. No hand mixed concrete is permitted for RCC works. Hand mixing if permitted for PCC works shall be carried out on a clean, hard and water tight platform. Water cement ratio shall be rigidly controlled during mixing. Mixers shall be fitted with automatic devices to discharge measured quantity of water to the mixing pan. The water shall not be admitted to the drum until the cement and



aggregate constituting the batch are thoroughly mixed. Mixing shall continue until the concrete is uniform in colour and not less than 2 minutes and forty (40) revolutions after all the material and water are in the drum. Regular checks on mixer efficiency shall be carried out as directed by the Engineer. Only those mixers whose efficiencies are within the tolerances specified in IS:1791 will be allowed to be employed. Batching plant where used shall conform to IS:4925. Concrete shall be prepared only by weigh batching the ingredients. Volume batching will not be permitted.

The entire content of the drum shall be discharged before the ingredients for next batch are fed into the drum. No partly set or remixed or excessively wet concrete shall be used. Such concrete shall be immediately removed from site. Each time the work stops the mixer shall be thoroughly cleaned and when the next mixing commences, the first batch shall have 10% additional cement at no extra cost to the Owner to allow for loss in the drum.

#### 9.5.5.6 Placing

Concrete shall be transported from the mixing plant to the forms, as rapidly as possible, by means which will prevent segregation, consolidation or drying out in hot weather. Concrete shall be placed within thirty (30) minutes after commencement of mixing. At the time of placing concrete in very hot weather, care shall be taken to see that the temperature of wet concrete does not exceed 38°C.

Before placing concrete, formwork, embedments and reinforcement shall be checked for completeness, location and dimension. It should also be square and plumb. All chips and saw dust or other foul matter shall be removed from within the forms with the help of an air compressor. The base surface shall be well moistened and puddles wiped up. Earth foundation on which direct placement of concrete is allowed will be rammed and consolidated as directed by the Engineer such that it does not crumble and get mixed up with the water during or after placement, before it has sufficiently set and hardened. Concrete may be placed against moist surface but never on pools of water. In case the foundation cannot be dewatered completely, special procedure and pre-caution, as directed by the Engineer will have to be adopted. A layer of mortar of thickness between 12 mm to 25 mm as directed, of the same or less W/C ratio and the same proportion as that of concrete being placed and /or cement slurry will be spread thoroughly on the foundation or construction joint just prior to placement of concrete. Placing equipment and accessories shall be kept clean and free of partially set grout and concrete, and maintained in proper working order. Walking on reinforcement layers is not permissible. Walkways of wooden planks or similar can be placed with removable supports and should be independent of reinforcement.

In general, placing shall be direct, by transporting buckets. Where it is necessary to deposit the concrete at level differences of more than 1.5 m, short chutes shall be used. Short chutes and hoppers shall be so designed and installed that segregation will not take place. In cases where chutes are impracticable due to excessive drop to placing level, hoppers and sectional tubes (elephant trunks) shall be used.

After the concrete has been placed, it shall be spread, if necessary and thoroughly worked around reinforcement or other embedded fixtures into concrete form and shape. Vibrators shall not be used for pushing the concrete into the adjoining areas. Care must be taken to ensure that the inserts, fixtures, reinforcement and formwork are not displaced during or immediately after the placement and bring the concrete surface out of the alignment beyond tolerance limits, the Engineer may direct to remove the portion and reconstruct or repair the same at the Contractor's expense.

The rate of placement of concrete shall be such that no cold joint is formed and fresh concrete is placed always against green concrete which is still plastic and workable. No concrete shall be placed in open, while it rains. During rainy season, no placement in open is to be attempted unless sufficient tarpaulins or other similar protective arrangement is

complete covering the still green concrete from rain is kept at the site of placement. If there has been any sign of washing of cement and sand, the entire affected concrete shall be removed immediately.

#### 9.5.5.7 Compaction

Concrete in general shall be consolidated by vibration using high frequency mechanically driven vibrators. Concrete shall be placed in layers at least 300 mm deep in walls and approximately 450 mm in mass pouring. Vibrators shall not penetrate more than 50 mm into the surface of previously placed layers but shall completely vibrate the working layer. Care shall be taken not to over-vibrate any concrete and especially those with higher slumps. Under no circumstances vibrators shall be attached to or allowed to touch reinforcement. Spare vibrators in good operating condition shall be on hand during placing operations.

#### 9.5.5.8 Construction Joints

In general, construction joints shall be limited to those indicated on the drawings. In mass concrete, construction joints may not be indicated in the drawings but shall be made at breaks, offsets or other convenient levels as controlled by volume, plant capacity and time factors. Such construction joints shall be so located that they do not impair the strength of the structure. In walls and columns, height of each lift shall not generally exceed 1.5 m unless otherwise specified in the drawings or directed by the Engineer. Method of forming all construction joints shall conform to the provisions of IS:456.

All construction joints shall be cleaned with wire brush and water to remove all laitance and loose material to expose the aggregates. Immediately before placing fresh concrete, the surface of previously placed concrete shall be coated with a thin coat of cement mortar slurry of the same proportion as that of concrete.

Where locations of the joints are not specified, it will be in accordance with the following:

- a. In a column, the joint shall be formed 75 mm below the soffit of the beam or the edge of the anchored bar of the beam framing into it whichever is lower. The Contractor shall refer to the beam reinforcement drawing before deciding on the location of the joint at column-beam junction.
- b. Concrete in a beam shall preferably be placed without a joint, but if provision of a joint is unavoidable, the joint shall be vertical and at the middle one third of the span, clearing the cross beam location, if any.
- c. A joint in a suspended floor slabs shall be vertical and at the middle one third of the span and at right angles to the principal reinforcement.
- d. In general, construction joints shall be located preferably in a low shear stress zone and at right angles to the direction of the principal stress

Any deviation from the above shall be approved by the Engineer.

#### 9.5.5.9 Curing and Protecting

As soon as the concrete has hardened sufficiently, it shall be covered either with Hessian, canvas or similar materials and kept continuously wet for at least seven (7) days after final setting. Curing by continuous sprinkling of water will be allowed if the Engineer is satisfied with the adequacy of arrangements made by the Contractor.

Curing of concrete with water shall comply with IS:456. Curing compound shall be used subject to approval by the Engineer. Finished floors shall be protected carefully until completely set. Protection of concrete against extreme weather conditions shall comply with the code.

**9.5.5.10 Finishing**

No touching-up will be permitted to the concrete after removal of formwork. Where damages, honey-combing or other unsatisfactory finishes have occurred to the concrete surfaces, they shall be rectified in a manner as directed by the Engineer, at no extra cost. If in the opinion of the Engineer the concreting is unsatisfactory, demolition of the entire concrete work and reconstruction of the same shall be carried out by the Contractor, as directed by the Engineer at his own cost.

**9.5.5.11 Formwork & Centering**

Form work in general shall conform to IS:456.

For complicated work, the contractor shall submit his proposal of formwork before starting the work for approval of the Engineer. The number of props, their sizes and dispositions shall be such as to be able to safely carry the full dead load and constructional loads. However, approval of the Engineer to this effect shall not relieve the contractor of his responsibility for proper work and safety.

All forms of beams, slabs and members shall be so designed and erected that the sides can be removed without disturbing the soffit shutter and supports there to.

Beam soffit shall be provided with an upward, camber of 6mm for each 3 m of horizontal span or as directed by the Engineer. Vertical props shall be supported on wedges or sole plates or other measures where by the props can be gently lowered while commencing to remove the shuttering. Columns shuttering shall not be over 1.5 m in height a piece.

Before removal of the shuttering the concrete shall be examined and its removal order taken from the Engineer. In no circumstance shall forms be struck until the concrete reaches a strength of atleast twice the stress to which the concrete may be subjected at the time of striking.

Shuttering shall not be removed until the number of clear days specified in IS:456 have elapsed since the last day of placing concrete in the member concerned. All formwork shall be removed without such shock or vibration as would damage the reinforced concrete. Before the soffits and struts are removed, the concrete surface shall be exposed, where necessary, in order to ascertain that the concrete has sufficiently hardened. The specified period may be extended if desired by the Engineer on account of delayed hardening caused by low atmospheric temperature.

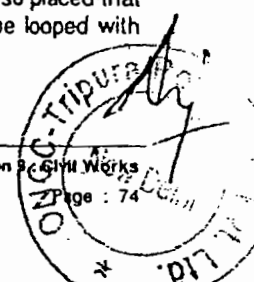
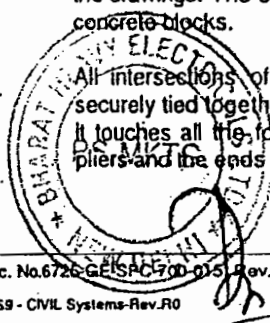
**9.5.5.12 Reinforcement**

The reinforcement bending shall be carried out as per the approved bar bending schedule prepared based on design drawing.

Workmanship shall conform to IS:2502. All reinforcement shall be free from loose mill scale, rust, oil, grease and paint. Reinforcement shall not be bent or straightened in a manner that will injure the materials and all bars shall preferably be bent cold. Hot bending shall not be permitted for bars whose strength have been increased by cold working.

Reinforcement bars shall be placed and maintained accurately in positions as shown in the drawings. The correct cover to the reinforcement shall be maintained by use of precast concrete blocks.

All intersections of longitudinal and transverse bars or stirrups and all laps shall be securely tied together with approved binding wire. The binding wire shall be so placed that it touches all the four corners of the intersection and the two ends shall be looped with pliers and the ends shall be turned into the body of the concrete.



Welded joints may be used but in all cases of important connections, tests shall be made to prove that the joints are of the full strength of bars connected. Welding shall be done in accordance with IS:2751 and IS:9417. Butt welding between the ends of a rod in line, whereby stress is transferred across the section may be adopted only for mild steel bars. In case of tack welding for fixing reinforcements in their position, no special precaution need be taken.

#### 9.5.5.13 Steel Embedments

All embedments shall be accurately set, rigidly fastened and suitably anchored by welding lugs. Anchor bolts shall be set to template and firmly secured in vertical and horizontal line and required positions. The guidelines furnished by equipment supplier / vendor shall be taken in to account

Exposed surfaces of embedded materials are to be painted with one coat of red oxide zinc chrome and/ or bituminous paint. Correct location and alignment of all anchor bolts, anchor sleeves, inserts, hangers, conduit pipes and other embedded fixtures as per drawings/instruction shall be entirely the responsibility of the Contractor.

#### 9.5.5.14 Expansion & Isolation Joints

##### General

Expansion and Isolation joints in concrete structures shall be provided at specified places, as per details indicated on the drawings. The materials and types of joints shall be as specified hereinafter. In case of liquid retaining structures, additional precautions shall be taken to prevent leakage of liquids as may be specified on the drawings or as directed by the 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 free of cost to the Owner. Approved samples of the material to be incorporated in the works shall be with the Engineer. 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.

##### Bitumen Board

Bitumen impregnated fiber board of approved manufacturer as per IS:1838 may be used as fillers for expansion joints. It must be durable and water proof. It shall be compressible and possess a high degree of rebound. The dimensions of the board should be equal to that of the joint being formed. It should, preferably be manufactured in one piece, matching the dimension of the joint and not prepared by cutting to size smaller pieces from larger boards at site. At the exposed end, the joint shall be sealed with approved sealing compound to a depth of at least 25 mm after application of an approved primer. The sealing compound and the primer shall be applied as specified by the manufacturer.

##### 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.

##### Joint Filler

The concrete surface shall be made clean, smooth and free from dirt or loose particles. When the surface is completely dry, a coat of hot blow bitumen conforming to IS:702 of

grade 85/25 shall be given with brush or spray. When the bitumen is still hot, the premoulded joint filler fibre board shall be pressed against the surface and held in position till the time it takes to adhere. When more than one layer of filler are specified each layer shall be made to adhere to the preceding layer with a few patches of bitumen between the two layers. After placing the filler in position, the surface of the filler against which further concreting is to be done is given a coat of bitumen.

#### Joint sealing compound

Sealing compound shall be of Grade A conforming to IS: 1834. Bitumen shall conform to IS:3384.

Before application of the sealing compound the sides of the joint are sprayed or brushed with bitumen primer. The primer is then allowed to dry out thoroughly for at least 24 hours and then filled with a mix of 30 % fine sand and 70 % sealing compound by weight.

#### Joint Sealing Strips/Water Stops

Joint sealing strips may be provided at the construction, expansion and isolation joints as a continuous diaphragm to contain the filler material and/or to exclude passage of water or any other material into or out of the structure. The sealing strips will be either metallic like G.I., Aluminium or non-metallic like P.V.C.

Sealing strips shall not have any longitudinal joint and shall be procured and installed in largest practicable lengths having a minimum number of transverse joints. The jointing procedure shall be as per the manufacturer's recommendations, revised if necessary, by the Engineer.

#### Metal Sealing Strips

Metal sealing strips shall be either G.I., or Aluminium and formed straight, U shaped, Z shaped or any other shape and of thickness as indicated in the drawing and/ or as instructed by the Engineer.

The transverse joints will be gas welded using brass rods and approved flux and will be tested by an approved method to establish that it is leak proof. In case it is found that the joints cannot be made leak proof, longer lap length and different method of brazing which will render it leak proof, will be adopted by the Contractor. The edges shall be neatly crimped and bent to ensure proper bond with the concrete.

**G.I. Strips :** G.I. Strips shall be minimum 1.5 mm thick and 150 mm in width unless specified otherwise. The standard of Galvanising shall be as per relevant Indian Standards for heavy duty work. The strips shall be strong, durable, without any rust or crease. At the joints, the over-lapping should be for a minimum length of 50 mm.

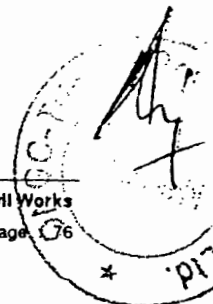
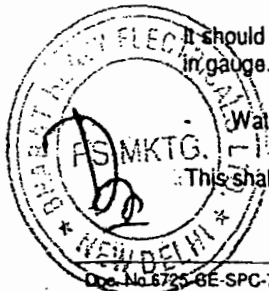
#### Aluminium

**Strips :** Aluminium strips shall be minimum 18 swg. thick and 300 mm wide unless specified other wise and shall conform to IS:737 of 19000 grade or 31000 grade (Designation as per IS:6051). A minimum lap of 50 mm length is required at the joints.

It should be cleaned thoroughly before use to expose fresh surface, without any reduction in gauge. A minimum lap of 50 mm length is required at the joints.

#### Water stops

This shall be of P.V.C. having any combination of the following features :



- a. Plain
- b. Central bulb
- c. Dumb-bell or flattened ends
- d. Ribbed and Corrugated Wings
- e. V-shaped

Transverse joints will be allowed only under unavoidable circumstances and with the specific approval of the Engineer. The method of forming these joints, laps etc. shall be specified by the Manufacturer and/or as approved by the Engineer, taking particular care to match the central bulbs and the edges accurately.

The minimum thickness of P.V.C water stops shall be 8 mm and the minimum width 150 mm. The actual size and shape will be as shown in drawings and/or as directed by the 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. PVC water stops used in water retaining structures shall be able to withstand the water pressure to which it will be subjected to.

#### Bitumen Compound

When directed, the gap in expansion joints shall be thoroughly cleaned and bitumen compound laid as per manufacturer's specifications. The compound to be used shall be of approved manufacturer and shall conform to the requirements of IS:1834.

#### Isolation Joints

Strong and tough alkathene sheet or equivalent, about 1 mm in thickness and as approved by the Engineer shall be used in Isolation Joints. It shall be fixed by an approved adhesive compound on the cleaned surface on the already set concrete, to cover it fully. Fresh concrete shall be laid against the sheet, care being taken not to damage the sheet in any way.

#### Rubber Pad

Hard foundation quality rubber pads of required thickness and shapes shall be used below machine or other foundation for vibration isolation. The rubber shall have a unit weight of 930 Kg/m<sup>3</sup>, shore hardness - 65 A to 70 A and be of best quality of approved manufacturer, durable, capable of absorbing vibration and must be chemically inert in contact with moist or dry earth or any other deleterious material expected under normal conditions.

#### 9.5.5.15 Precast Concrete

All precast work shall be carried out in a yard for the purpose. This yard shall be dry, properly levelled and having a hard and even surface. If the ground is to be used as a soffit form for the units, it shall be paved with concrete or masonry and provided with a layer of cement plaster with smooth neat cement finish or a layer of M.S. sheeting. Where directed by the 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 seven (7) days of curing and can be removed for erection after twenty eight (28) days of curing. The moulds shall preferably be of steel or of timber lined with G.I. sheet metal. The yard shall preferably be fenced.

Lifting hooks, where necessary or as directed by the 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 removed and the hooks finished after erection if directed by the Engineer.

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. Chipped or cracked or otherwise damaged pre-cast elements will be rejected.

After erection and alignment, the joints shall be filled with grout or concrete as directed by the 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 fourteen (14) days. The joint between precast roof planks shall be pointed with 1:2 cement : sand mortar unless otherwise shown in the drawings.

#### 9.5.5.16 Waterproofing of Concrete to Structures

##### General

Waterproofing of concrete structures shall be done by suitable extraneous treatments like applying paints, fixing bitumen felts polymeric membrane, installing water bars at construction joints etc.

The design, material and workmanship shall conform to the relevant I.S. codes where applicable. The 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 best quality available indifferently, and suitable for the duties called upon.

##### Water Stop

Water bearing structures and underground structures shall have PVC water stops installed at the joints. Installation will be as described under "Expansion & Isolation Joints".

##### Waterproofing Admixtures

###### In Concrete

The admixture shall be procured from reliable and reputed manufacturers and approved by the Engineer. The method of application and other details shall conform to the manufacturer's specification and/or as instructed by the Engineer.

###### in Plaster

The concrete surface, to be plastered, shall be hacked to Engineer's satisfaction, cleaned thoroughly and kept wetted for 24 hours. The plaster shall be in cement sand mortar mixed in proportion varying from 1:1 to 1:4 by volume along with the approved waterproofing admixture and laid in appropriate thickness and in layer not exceeding 15 mm or as per manufacturer's specification. The additive shall be of quality and type approved by the Engineer. On completion, the plastered surface shall be cured continuously for a minimum period of fourteen (14) days like concrete.

##### Bituminous or Tar Coating

The surface to be waterproofed shall be rendered absolutely dry, clean and dust free. The surface shall be sand papered, cleaned and completely coated with hot coal tar pitch of approved manufacture and quality as per IS:216 (not heated above 375°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°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.

#### 9.5.5.17 Testing Concrete Structures for Leakage

Hydro-static test for water tightness shall be done at full storage level or soffit of cover slab, as may be directed by Engineer, as described below ( In compliance with IS:3370):

In case of structures whose external faces are exposed, such as elevated tanks, the requirements of the test shall be deemed to be satisfied if the external faces show no sign of leakage or sweating and remain completely dry during the period of observation of seven days after allowing a seven day period for absorption after filling with water.

In the case of structures whose external faces are submerged and are not accessible for inspection, such as under ground tanks, the structures shall be filled with water and after the expiry of seven days after the filling, the level of the surface of the water shall be recorded. The level of water shall be recorded again at subsequent intervals of 24 hrs. over a period of seven days. Backfilling shall be withheld till the tanks are tested. The total drop in surface level over a period for seven days shall be taken as an indication of the water tightness of the structure. The Engineer shall decide on the actual permissible nature of this drop in the surface level, taking into account whether the structures are open or closed and the corresponding effect it has on evaporation losses. Unless specified otherwise, a structure whose top is covered shall be deemed to be water tight if the total drop in the surface level over a period of seven days does not exceed 40 mm. For open type, it shall be 60mm.

Each compartment/segment of the structure shall be tested individually and then all together.

For structures such as pipes, tunnels etc. the hydrostatic test shall be carried out by filling with water, after curing as specified, and subjecting to the specified test pressure for specified period. If during this period the loss of water does not exceed the equivalent of the specified rate, the structure shall be considered to have successfully passed the test.

Any leakage that may occur during the hydro-test or subsequently during the defects liability period or the period for which the structure is guaranteed shall be effectively stopped either by cement/epoxy pressure grouting, guniting or such other methods as may be approved by the Engineer. All such rectification shall be done by the Contractor at his own cost to the entire satisfaction of the Owner/Engineer.

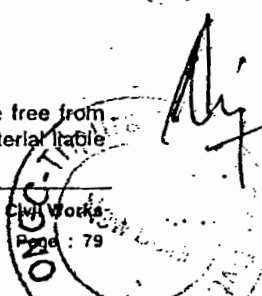
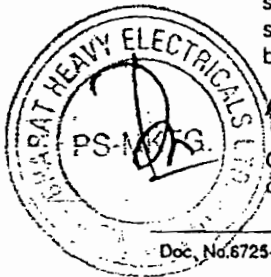
#### 9.5.5.18 Testing of Materials

##### Cement

The Contractor shall submit to the Engineer the manufacturer's certificate for each consignment of cement procured by him. If required by the Engineer, representative samples shall taken from each consignment and tests for fineness (by hand sieving), setting time and compressive strengths as per IS:269 shall be carried out, free of charge by the Contractor.

##### Aggregates

Coarse and fine aggregate and the grading shall be as per IS:383. It shall be free from organic or clay coatings and other impurities, flaky particles, and any other material liable



to affect the strength, durability or appearance of concrete. Washing of aggregates by approved means shall be carried out, if desired by the Engineer.

The Contractor shall carry out all the tests on aggregates as may be required by the Engineer in accordance with IS:2386. The records of these shall be maintained and made available by the contractor for the checking of Engineer. The acceptance criteria of samples tested shall be in accordance with the requirements of relevant Indian Standards.

#### Admixture

##### - Air Entraining Agents

Initially, before starting to use Air Entraining Agents, relationship between percentage of air entrained and the cylinder cube crushing strength vis-à-vis quantity of Air Entraining Agents used for all types of concrete will be established by the Contractor free of charge by carrying out sufficiently large number of tests. After that, at regular intervals and whenever directed by the Engineer, the Contractor will check up free of charge, the actual percentage of air entrained and corresponding curing strengths to correlate with the earlier test results.

##### - Other Admixture

Tests for establishing the various properties of any other admixtures which may be required to be added shall be carried out by the Contractor free of charge to the Owner.

Usage of admixtures shall be purely subjected to the approval of Engineer or Owner's Engineers.

#### Concrete

Sampling, curing and testing of specimen will comply with IS:1199 and IS:516. Sampling procedure, shall generally conform to IS:456. Sampling frequency for each grade of concrete M20 and above shall be as per relevant IS codes.

In case, the stripping time for shuttering needs to be reduced or early age strength is required to be known in specific cases, the Contractor shall carry out at short notice testing of cubes at one (1) day and three (3) days after accelerated curing as per IS:9013. The required number of additional samples for the same shall also be taken.

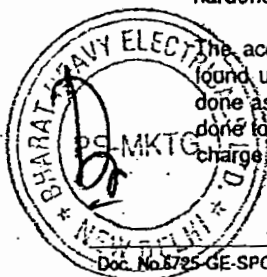
To control the consistency of concrete from every mixing plant/machine, slump tests and/or compacting factor tests as per IS:1199 shall be carried out by the Contractor every two hours or as directed by the Engineer in addition to the slump measured when making test cubes.

#### 9.5.5.19 Acceptance Criteria

##### Structural Criteria

Acceptance criteria of concrete shall be generally in accordance with IS:456. Immediately after stripping the formwork, all concrete shall be carefully inspected and any defective work or small defects either removed or made good before the concrete has thoroughly hardened.

The acceptance criteria of concrete shall be in accordance with IS:456. Concrete work found unsuitable for acceptance shall have to be dismantled and replacement is to be done as per specification by the Contractor. In the course of dismantling, if any damage is done to the embedded items or adjacent structures, the same shall be made good, free of charge by the Contractor, to the satisfaction of the Engineer.



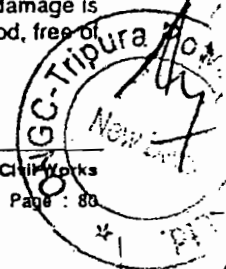
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**Dimensional Criteria**

The permissible variation from dimension, lines given in the drawing shall be within tolerances specified below. Wherever tolerances are not specified below the same shall be in accordance with the relevant IS codes/other applicable national/international standards or as indicated by the Engineer.

## - Tolerances for R.C. Buildings :

## i) Variation from the plumb

- In the lines and surfaces of columns, piers, walls and in arises. : 5 mm per 2.5 m or 25 mm, whichever is less

## - For exposed corner columns and other conspicuous lines

In any bay or 5 m max. : 5 mm  
In 10 m or more : 10 mm

## ii) Variation from the level or from the grades indicated on the drawings

## - In slab soffits, ceilings, beam soffit, and in arises

In 2.5 m : 5 mm  
In any bay or 5 m max. : 8 mm  
In 10 m or more : 15 mm

## - For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines

In any bay or 5 m max. : 5 mm  
In 10 m or more : 10 mm

## iii) Variation of the linear building lines from established position in plan and related position of columns, walls and partitions.

In any bay or 5 m max. : 10 mm  
In 10 m or more : 20 mm

## iv) Variation in the size and locations of sleeves, - 5 mm except openings in walls and floors in the case of and for anchor bolts

## v) Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls

Minus (-) : 5 mm  
Plus (+) : 10 mm

## vi) Footings

## - Variation in dimension in plan

Minus (-) : 5 mm  
Plus (+) : 50 mm

- Misplacement or eccentricity : 2% of footing width not more than 50 mm of misplacement but in the direction

- Variation in thickness  
Minus (-) : 5% of specified thickness subject to a  
max. of 50mm

Plus (+) : 100 mm

## vii) Variation in steps

## - In a flight of stairs

Riser : 3 mm

Tread : 5 mm

## - Inconsecutive steps

Riser : 1.5 mm

Tread : 3.5 mm

## - Tolerances in other Concrete Structures

## i) All structures other than those covered in ii) below.

## - Variation of the constructed linear outline from established position in plan

In 5 m : 10 mm

In 10 m or more : 15 mm

## - Variations of dimensions to individual structure features from established positions

In 20 m or more : 25 mm

In buried construction : 50 mm

## - Variation from plumb, from specified batter or from curved surfaces of all structures

In 2.5 m : 10 mm

In 5 m : 15 mm

In 10 m or more : 25 mm

In buried construction : Twice the above amounts

## - Variation from level or grade indicated on drawings in slab, beams, soffits, horizontal grooves and visible arises.

In 2.5 m : 5 mm

In 7.5 m or more : 10 mm

In buried construction : Twice the above amounts

## - Variation in cross-sectional dimensions of columns beams, buttresses, piers and similar members

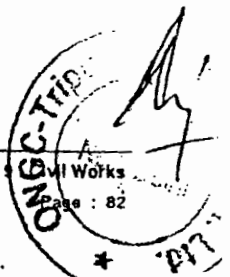
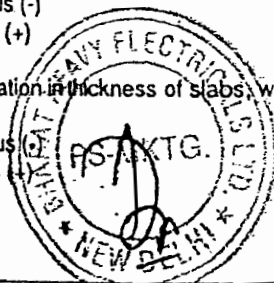
Minus (-) : 5 mm

Plus (+) : 10 mm

## - Variation in thickness of slabs, walls, arch sections and similar members

Minus (-) : 5 mm

Plus (+) : 10 mm



## ii) Footing for columns, piers, walls, buttresses and similar members

## - Variation of dimension in plan

Minus (-)	:	5 mm
Plus (+)	:	10 mm

## - Misplacement or eccentricity

2% of footing width in the direction of misplacement but not more than 50 mm

## - Reduction in thickness

5% of specified thickness subject to a max. of 50 mm

Tolerances in other types of structures not covered above shall generally conform to those given in Recommended Practice for Concrete Formwork (ACI 347)

Tolerances in fixing anchor bolts and embeded parts shall be as follows :

- Anchor bolts without sleeves	:	(±) 1.5 mm in plan
- Anchor bolts with sleeves	:	(±) 5.0 mm in elevation
- For bolts upto and including 28 mm dia	:	(±) 5 mm in all directions
- For bolts 32 mm dia and above	:	(±) 3 mm in all directions
- Embedded parts	:	(±) 5 mm in all directions
- Tolerances in precast members	:	

## i) Length

Upto 3 m	:	(±) 6 mm
3 m to 4.5 m	:	(±) 9 mm
4.5 m to 6 m	:	(±) 12 mm
Additional for every subsequent 6 m	:	(±) 6 mm

## ii) Cross Section (Each direction)

Upto 50 cm	:	(±) 6 mm
50 cm to 75 cm	:	(±) 9 mm
Additional for every subsequent 25 cm	:	(±) 3 mm

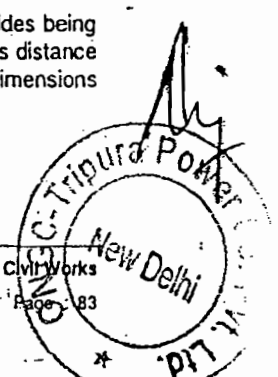
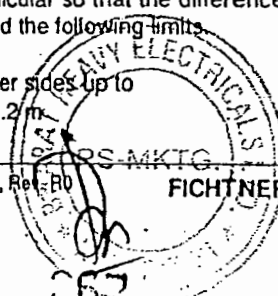
## iii) Straightness or bow (Deviation from intended line)

Upto 3 m	:	6 mm
3 m to 6 m	:	9 mm
6 m to 12 m	:	12 mm
Additional for every subsequent 6 m	:	6 mm

## iv) Squareness

When considering the squareness of a corner, the longer of the two adjacent sides being checked should be taken as the base line. The shorter side should not vary in its distance from a perpendicular so that the difference between the greatest and shortest dimensions does not exceed the following limits.

Length of shorter sides up to and including 1.2 m : 6 mm



Over 1.2 m but less than 2 m	:	9 mm
2 m and over	:	12 mm

For the purpose of this requirement, any error due to lack of straightness should be ignored; squareness should be measured with respect to the straight lines which are most nearly parallel with the features being checked.

v) Flatness

The maximum deviations from a 1.5 m straight edge placed in any position on nominally plane surface should not exceed 6 mm.

#### 9.5.5.20 STORAGE AND HANDLING OF MATERIALS

##### Cement

Cement shall be stored in easily countable stacks with consignment identification mark above ground level in perfectly dry and watertight sheds. Bulk cement shall be stored in air tight containers. Cement shall be stored in a manner so as to facilitate removal of first-in first-out basis. Any cement considered defective by the Engineer shall not be used by the Contractor and shall be removed from the site immediately. Cement that has been in store for three (3) months or more shall be tested for quality. Should at any time the Engineer has reasons to consider that any cement is defective, then irrespective of its origin, date of manufacture and manufacturer's test certificate, such cement shall be tested immediately at the Contractor's cost at an approved laboratory and until the test results are found satisfactory, the cement shall not be used on any work. The Contractor is not entitled to any claim of any nature on this account.

##### Coarse and fine aggregate

Aggregates shall be stored in easily measurable stacks on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass or any other injurious substances at any stage. Aggregate of different size shall be kept in different stacks. If so desired by the Engineer, aggregate from different sources shall be stacked separately with proper care to prevent intermixing.

Any aggregate delivered at site in a wet condition or becoming wet at site due to rain or any other means shall be kept in storage for atleast twenty four (24) hours to obtain adequate drainage before it is used for concreting or the water content of the mix must be suitably adjusted as directed by the Engineer.

##### Reinforcement

Reinforcement bars shall be stored off the ground under all circumstances and under cover, if so desired by the Engineer. If necessary, a coat of cement wash shall be given to bars to guard against rusting. Reinforcing steel shall be stored consignment wise and diameter wise.

#### 9.5.6 Turbo Generator Foundations

##### 9.5.6.1 Scope

This specification covers specific requirements in regard to formwork, staging and placing of concrete for the construction of turbo-generator foundation and pedestal. The requirements specified below shall be in addition to the general requirements as specified in 9.5.5 for Plain & Reinforced Concrete Works. Although the specification covers the requirements for STG foundation, the same is applicable for GTG foundation also.



## 9.5.6.2 Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

IS:456	Code of practice for plain and reinforced concrete
IS:2974(Part 3)	Code of practice for design and construction of machine foundation - Foundation for rotary type machines (Medium and high frequency).

## 9.5.6.3 Formwork

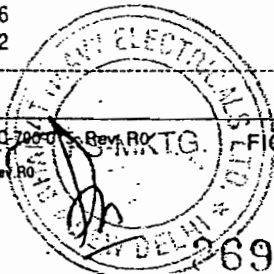
## Design of Formwork

The design of Form work shall take into account all vertical and lateral loads that the forms will carry or be subjected to, during the construction process. Besides weight and pressure of reinforced concrete and weight of the forms themselves, the design shall consider loadings due to unsymmetrical placement of concrete; impact from dumping of concrete; concentrated loads produced by storing materials on the freshly placed concrete; movement of men and construction equipment; wind action and any other imposed load during construction. Contractor shall assess the magnitude of vertical live load to be taken for design of formwork duly considering his method, sequence and rate of pour of concrete. However, minimum design vertical live load to be considered shall be 750 Kg/m<sup>2</sup> excluding weight of concrete.

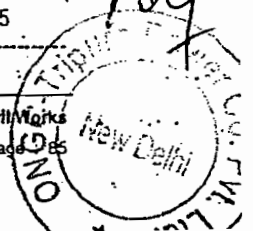
Staging for the deck slab shall be supported directly from the TG raft independent of the TG pedestal columns already cast.

Side shuttering shall be designed to cater for concrete pressures, duly considering rate of pour, temperature of concrete, slump and rate of vibration. The column shuttering shall be designed for a rate of vertical pour not less than 4 metres per hour. For shuttering of deck slab of pedestal, the design rate shall not be less than 1.5 metres per hour. Concrete temperature for design purpose shall be taken to be 21°C (or 70°F) or less. Lateral pressures for design of forms shall be based on ACI Committee 622 Pressure Formula or CERA Research Report No.1 Pressure Design Chart. Following Table, based on ACI Committee 622 Pressure Formula, is given as guidance for assessing maximum lateral pressure for design of forms. Pressure in excess of 2400 Kg/m<sup>3</sup> x height of fresh concrete in metres shall not be considered.

Rate of Concrete placement in metre per hour	Maximum lateral pressure in Kg/cm <sup>2</sup> for temperature indicated		
	21°C (70°F)	15°C (60°F)	10°C (50°F)
1.5	3870	4395	5125
1.8	4500	5125	6005
2.1	5130	5860	6885
2.4	5750	6590	7765
3.0	7010	8055	9520
3.6	8265	9520	11280
4.2	9520	10985	13035



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**Materials for Formwork**

Scaffolding, props, struts and bracings for the shuttering of TG pedestal shall be of structural steel. Plywood faced shuttering shall be used for achieving smooth exposed concrete finish.

**Wall ties/through bolts**

Through bolts, when used as wall ties, shall be in one single piece for the full length.

Through bolt diameter and spacing should be designed to cater for entire lateral concrete pressure on the shuttering. In addition, side stays shall be provided to take atleast 50% of the specified design pressure.

Where use of through bolts is not feasible, the entire pressure shall be taken by side stays/props.

Welding of through bolts to reinforcement shall not be permitted.

**Platforms/Windows**

Suitable and adequate working platforms shall be provided at TG deck slab level, all round the TG pedestal for easy access for construction and inspection.

Adequate windows at maximum 2 m vertical spacings shall be provided in column shuttering for concreting, inspection and introducing vibrators. Arrangements should be made for closing tightly the windows to prevent loss of water and fine material from concrete, as the pour level overtakes the window level.

**Inserts/Embedments**

Inserts/embedments shall not be supported on or tied to reinforcement, but independently on shuttering. If the embedments are to be welded, separate rebars have to be provided for the purpose. Suitable arrangements shall be made to locate and fix them to shuttering. Stools shall be provided where required.

Main equipment foundation bolts, pipe sleeves and block-outs for pockets shall be placed and maintained in position at the top by means of an adequately braced steel template. While planning the template, care should be taken to ensure that it does not block the top of beam and that adequate free space is left to pour concrete from the top.

**Placing of Concrete**

Contractor shall furnish to Engineer together with formwork design, his proposed scheme for concreting the TG base raft and pedestal. The scheme shall indicate types of equipment, mobilisation of men and materials, standby arrangements and method, sequence and rate of pouring concrete. Work shall proceed only after Engineer's approval.

Concrete for TG raft and TG deck slab be cooled to a temperature of 23°C and adequate arrangements shall be made to ensure this. Concrete for columns shall be cooled if the least dimensions of column is more than 1.4m.

The base raft shall be cast in not more than two pours or as shown on the drawing. Full raft thickness shall be achieved in each continuous pour. Extent of each pour and sequence of pours shall be as directed by Engineer or as shown in drawing released for construction.

TG pedestal columns from top of base raft to bottom of TG deck etc., shall be cast in one single continuous pour, unless otherwise directed by Engineer or as shown in drawings released for construction.

TG deck slab shall be cast in a single pour without construction joints/cold joints. Successive layers shall be placed before initial set of previous layer or within one hour, whichever is earlier. For proper placement and vibration, the layers shall not be less than 500 mm thick.

Chutes/tremie pipes of adequate dia (225 mm) shall be used to place concrete if the beams are more than 2.m deep and for this purpose, some top bars will have to be displaced temporarily to allow inserting of the same.

In areas where second stage grouting is to be done after the TG set is erected and aligned, the concrete shall be laid 50 mm higher than the actual level required and chipped back to exact required level. The concrete surface under equipment sole plates shall be ground to ensure a minimum contact area of 85%.

#### Tolerances In TG Foundation

Concreting of TG foundation (raft & pedestal) shall be to following tolerances in horizontal and vertical directions:

- Foundation dimensions	:	± 10 mm
- Location of embedded anchor bolts	:	± 5 mm
- Location of sleeves for piping and through holes for anchor bolt	:	± 10 mm
- Others	:	As specified in Clause 9.4.5 - Technical Specifications for "Plain & Reinforced Concrete Work"

#### 9.5.7 Prestressed Concrete

##### 9.5.7.1 Scope

This specification covers the requirements in respect design, workmanship and quality of pre-stressed concrete structures. It is supplementary to and has to be read in conjunction with the specification of plain and reinforced concrete work in Clause 9.4.5.

##### 9.5.7.2 Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship and methods & procedures of testing. Some of the relevant available codes are listed hereunder.

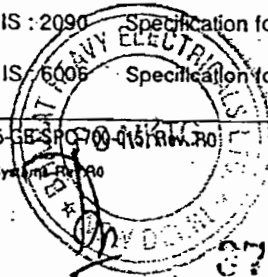
IS : 1343 Code of practice for the prestressed concrete.

IS : 1785 Specification for plain hard drawn steelwire for prestressed concrete.

IS : 6003 Specification for intended wire for prestressed concrete.

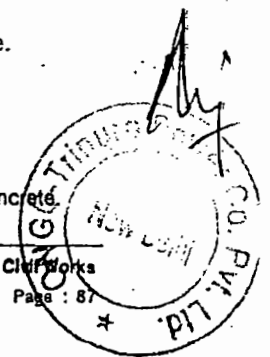
IS : 2090 Specification for high tensile bars for prestressed concrete.

IS : 6005 Specification for uncoated stress relieved strand for prestressed concrete.



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**9.5.7.3 Materials****Prestressing Steel**

Prestressing steel shall conform to IS:1785, IS:2090, IS:6003 and IS:6006.

**Non-tensioned Reinforcement**

Non-tensioned reinforcement may be mild steel bars conforming to IS:432 or high yield strength deformed bars conforming to IS:1786.

For other materials refer specification for plain and reinforced concrete work.

**9.5.7.4 Grades and Proportioning**

For prestressed concrete construction, only controlled concrete shall be used. The design of the concrete mix shall conform to the requirements laid down for controlled concrete under relevant clauses of IS:456, and the workmanship shall conform to specification for cement concrete subject to the following further conditions :

- i) The minimum cube strength of concrete at 28 days where ordinary portland cement is used, and at 7 days where rapid hardening portland cement is used on 15 cm cubes, shall not be less than 45 N/mm<sup>2</sup> for pre-tensioned system and 35 N/mm<sup>2</sup> for post-tensioned systems.
- ii) The mix shall contain not less than 380 kg of cement per m<sup>3</sup> of concrete for pre-tensioned work. The corresponding value of the post-tensioned work shall be 360 kg/m<sup>3</sup> of concrete. The cement in the mix shall not normally exceed 530 kg/m<sup>3</sup> of concrete.
- iii) The mix shall contain as low a water content as consistent with adequate workability.
- iv) The concrete shall be compacted thoroughly by vibration, pressure, shock, spinning or other means and shall have a density of not less than 24 KN/m<sup>3</sup>.

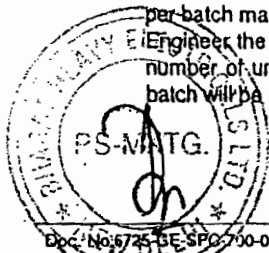
**9.5.7.5 Workmanship**

Workmanship and method of execution shall conform to the requirements of IS:1343.

The type of jack, like hydraulic jack, etc. used for prestressing shall be standard type and of approved manufacture. The method of anchorage shall be also of approved type so as not to allow more than nominal slip in the wires. The anchorage shall be safe and secure against both dynamic and static loads as well as against impact.

**9.5.7.6 Testing and Acceptance Criteria**

Sampling, strength test and acceptance of precast prestressed members shall be in accordance with the provisions of IS:456 & IS:1343. The contractor shall conduct load test on one random piece per batch or 1000 units precast. Load test on more than one piece per batch may have to be done if required by the Engineer. The Contractor shall inform the Engineer the number of units that would be cast in a single operation based on which the number of units to be tested will be decided. If a piece/unit fails in a load test the entire batch will be rejected.



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## Structural Steelwork

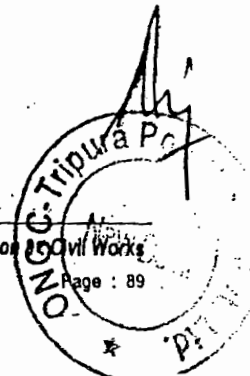
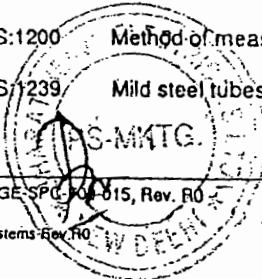
### 9.5.8.1 Scope

This specification covers the requirements in respect of materials, workmanship and quality for preparation of fabrication drawings, supply, fabrication, inspection, testing, painting and erection of structural steelwork including tubular steel work for buildings and structures.

### 9.5.8.2 Codes and Standards

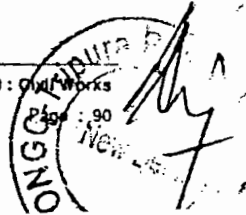
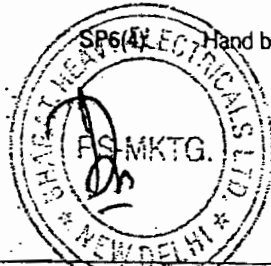
Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed here under:

- IS:800 Code of Practice for use of structural steel in general building construction.
- IS:801 Code of Practice for use of cold formed light gauge steel structural members in general building construction.
- IS:806 Code of Practice for use of steel tubes in general building construction.
- IS:808 Dimensions of hot rolled steel sections.
- IS:813 Scheme of symbols for welding.
- IS:814 Covered electrodes for metal arc welding of structural steel.
- IS:815 Classification and coding of covered electrodes for metal arc welding of mild 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 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 Practice for inspection of welds.
- IS:919 Recommendations for limits and fits for engineering.
- IS:961 Structural Steel (High Tensile).
- IS:1148 Hot-rolled rivet bars for structural purposes.
- IS:1149 High tensile rivet bars for structural purposes.
- IS:1161 Steel tubes for structural purposes.
- IS:1200 Method of measurement of steel work and Part VIII Iron work.
- IS:1239 Mild steel tubes, tubular and other wrought steel fittings.



IS:1363	Hexagon head bolts, screws and nuts of product
IS:1364	Hexagon head bolts, screws and nuts of product g
IS:1367	Technical supply conditions for threaded steel fasteners.
IS:1442	Covered electrodes for metal arc welding of high tensile structural steel.
IS:1609	Method for tensile testing of steel products.
IS:1730	Dimensions for steel plate, sheet and strip for structural and general engineering purposes.
IS:1731	Dimensions for steel flats for structural and general engineering purposes.
IS:1852	Rolling and cutting tolerances for hot-rolled steel products.
IS:1977	Structural steel (ordinary quality) St-42-0.
IS:2062	Weldable structural steel.
IS:2074	Ready mixed paint, air drying, red oxide zinc-chrome, priming.
IS:2633	Methods of testing uniformity of coating on zinc coated articles.
IS:3757	High strength structural bolts.
IS:4000	High strength bolts in steel structures - Code of Practice.
IS:5369	General Requirements for Plain Washers and Lock Washers
IS:5372	Taper washers for channels (ISMC)
IS:5374	Taper washers for I-beams (ISMB)
IS:6610	Specification for Heavy Washers for Steel Structures
IS:6649	Specification for Hardened and Tempered Washers for High Strength Structural Bolts and Nuts
IS:6623	Specification for High Strength Structural Nuts
IS:7205	Safety code for erection of structural steelwork.
IS:7215	Tolerances for fabrication of steel structures.
IS:9595	Recommendations of metal arc welding of carbon and carbon manganese steels.
AISC	American Institute of Steel Construction Specification for the Design, Fabrication and Erection of Structural Steel for Buildings.

SP6(4) Hand book for use of high strength friction grip bolts.



**9.5.8.3 Materials****Structural steel**

All structural steel shall be of tested quality and shall conform to IS:2062. High tensile steel, when supplied, shall conform to IS:961.

**Bolts and nuts**

Bearing bolts and nuts shall conform to IS:1363 and IS:1364 and unless shown or specified otherwise shall be hexagonal. All nuts shall fit tight. Mechanical properties shall conform to IS:1367. High strength friction bolts shall conform to IS:3757 and nuts to IS:6623.

**Washers**

Washers shall conform to IS:5369, IS:5372, IS:5374, IS:6610 and IS:6649 as applicable.

Plain washers shall be made of mild steel, unless otherwise specified. Spring washers shall be provided for those parts which carry dynamic loads and where black bolts for connection are permitted.

**Electrodes**

Mild steel electrodes shall conform to IS:814 and high tensile steel electrodes to IS:1442. The manufactures shall have ISO certification. The Contractor shall furnish to the Engineer a certificate issued by the manufacturer to the effect that the electrodes supplied are in accordance with the above specifications. For welding in any particular position, the electrodes used shall be those recommended by the manufacturer for use in that position.

**Paints**

Paints to be used for shop coat of fabricated steel shall be compatible with the finish coat specified.

**Other Materials**

Other materials used in association with steel work shall comply with the appropriate Indian Standard specifications.

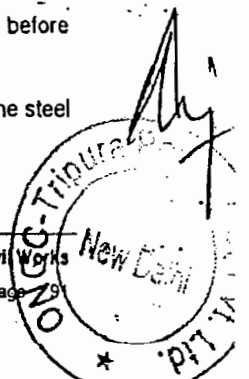
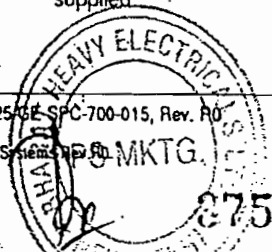
**General requirements regarding supply of materials by Contractor**

Before ordering bought out items, special accessories, equipment etc. and materials of any description, the Contractor shall submit, for the approval of the Engineer, the names of the proposed manufacturers or suppliers together with the specification of the materials and shall, thereafter, send to the Engineer copies of the orders.

When a supplier or sub-contractor orders materials for the execution of his sub-contract, he shall also comply with the aforesaid requirements, by the submission through the Contractor, for the approval of the Engineer, of the names of the manufacturers proposed and by sending to the Engineer of copies of the orders.

The Contractor shall furnish to the Engineer the following certificates, if required, before commencement of fabrication:

- i) A certificate stating the process of manufacture and chemical composition of the steel supplied



- ii) Test certificates by the manufacturer giving the results of each of the specified mechanical tests applied to the structural steel, bolts, nuts and washers and the chemical composition of the same.

#### 9.5.8.4 Drawings and Lists

Unless otherwise stated, the Contractor shall be responsible for the preparation of the detailed fabrication/working drawings, erection and marking plans and all necessary lists such as indents, rivet and bolt lists, material lists, Despatch lists and lists for all bought out items. The fabrication drawings shall indicate the size of each component and length and sequence of all welds & bolted connections.

Fabrication work shall not be taken in hand until the relevant shop drawings have been approved by the Engineer. Although these drawings receive the approval of the Engineer, the Contractor shall be wholly responsible for their being correct and complete. The drawings shall be supplied at least two weeks in advance to enable the Engineer to study the drawings. One copy of the approved drawings will be returned to the Contractor and the work shall be carried out according to the approved drawings.

#### 9.5.8.5 Fabrication

##### General

##### - Workmanship

All workmanship shall be equal to the best practice in modern structural shops. Greatest accuracy shall be observed in the manufacture of every part of the work and all similar parts shall be strictly interchangeable.

##### - Templates

Templates used throughout the work shall be all steel, steel bushed in such cases as the Engineer may consider necessary. In cases where actual materials have been used as templates for drilling similar pieces, the Engineer shall decide whether they are fit to be used as parts of the finished structure.

##### - Straightening

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

##### - Clearance

The erection clearances for cleated ends of members connecting steel to steel should preferably be not greater than 2.0 mm at each end. The erection clearance at ends of beams without web cleats should be not more than 3 mm at each end, but where for practical reasons greater clearance is necessary suitably designed seatings should be provided.

##### - Shearing, flame cutting and planing

Shearing or flame cutting may be used at the Contractor's option provided that a mechanically controlled cutting torch shall be used for the flame cutting and that the resulting edge shall be reasonably clean and straight. Sheared members shall be free from distortion at sheared edges.

The edges and ends of all flange plates and web plates of plate girders and built-up columns of plates, forming chords or web members of lattice girders and all cover plates, the ends of all angles, tees, channels and other sections forming the flanges of plate girders and columns and chords and web members of lattice girders shall be planed.

The ends of all stiffeners shall be planed or ground to fit tightly between the main angles or flanges. Care shall be taken to ensure a full bearing of the stiffeners at the supports and at other points where concentrated load is applied. The ends shall not be drawn or caulked.

The butting surfaces at all joints of girders or columns shall be planed so as to butt in close contact throughout the finished joint.

The ends of all built-up girders and of all columns shall be faced in a machine. The bearing surfaces of all slabs and plates for caps and bases of columns and for seatings for heavy girders shall be machined.

Unless clean, square and true to shape, all flame-cut edges shall be planed.

Cold sawn ends if reasonably clean and flame cut ends of sections not inferior to sawn ends in appearance need not be planed except for butting ends.

#### - Holing

Holes for black bolts shall be not more than 1.5 mm larger than the nominal diameter of the bolt, unless specified otherwise. All holes, except as stated here under shall be drilled to the required size or sub-punched 3 mm less in diameter and reamed thereafter to the required size. All matching holes for black bolts shall register so that a gauge 1.5 mm less diameter than the hole can pass freely through the members assembled for bolting. All holes for turned and fitted bolts shall be drilled and reamed, if necessary, to a tolerance of only plus 0.13 mm unless specified otherwise. When the number of thicknesses to be riveted exceeds three or the total thickness is 90 mm or more, the holes shall be drilled or reamed in position after assembly, except when steel-bushed jigs are used. The parts shall be firmly bolted together during such block drilling and taken apart for removal of burrs after drilling.

Holes in purlins, side sheeting, runners, packing plates and lacing bars may be punched full size.

All punching and sub-punching shall be clean and accurate and all drilling free from burrs.

No holes shall be made by gas cutting process.

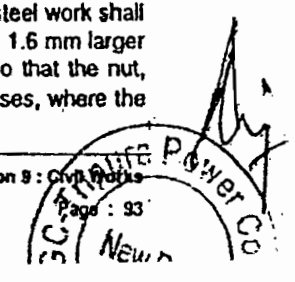
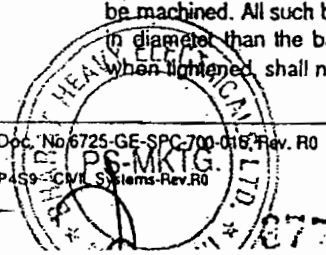
#### - Assembly

All parts assembled for bolting shall be in close contact over the whole surface and all bearing stiffeners shall bear tightly at both top and bottom without being drawn or caulked.

The component parts shall be so assembled that they are neither twisted nor otherwise damaged and specified cambers, if any, shall be provided.

#### - Bolting

Bolted construction shall be permitted only in the case of field connections, if called for on the drawings and is subject to the limitation of particular connections as may be specified. In special cases, however shop bolt connections may be allowed if directed by the Engineer. Unless otherwise specified, faces of heads and nuts bearing on steel work shall be machined. All such bolts shall be provided with washers having a hole of 1.6 mm larger in diameter than the barrel of bolt and thickness not less than 6.5 mm so that the nut, when tightened, shall not bear on the unthreaded body of the bolt. In all cases, where the



full bearing area of the bolt is to be developed, the threaded portion of the bolt should not be within the thickness of the parts bolted together. The threaded portion of each bolt shall project through the nut by at least one thread. Tapered washers shall be provided for all heads and nuts bearing on beveled surface.

#### - High Strength Friction Grip Bolting

Installation of high strength friction grip bolts in joints shall comply with IS:4000 and/or BS:3294. The diameter of the bolt holes must not be more than 2.0 mm larger than the nominal diameter of the bolt. All contact surfaces in a connection including those associated with the bolt heads, nuts and washers, shall be free of scale, burrs, dirt and other foreign matter tending to inhibit uniform sealing of the joint components. However, tight mill scale and the light residual oil coating on bolts, nuts and washers need not be removed.

All fasteners in a joint shall be tightened to a tension equal to or greater than the tension specified in Table 3 of IS:4000.

Tightening may be achieved by use of Direct tension Indication or part twin method. A hardened washer shall be placed under the element being turned. Bolts shall be tightened at the most rigid portion of the joint, proceeding towards the free edges. Procedure given in IS:4000 shall be followed.

Inspection of friction grip bolting shall ensure that the selected tensioning procedure has been correctly applied and all bolts are fully tensioned. The methods suggested in IS:4000 shall be used to check that all bolts are fully tensioned.

#### Welding

##### 1- General

The welding and the welded work shall conform to IS:816 unless otherwise specified. The permissible stresses for welding shall be taken as 75 per cent of those specified in IS:816, where welds are not tested by either radiographic or ultrasonic methods. All butt welds in critical structures such as crane girders, heavy columns, bunkers, etc. shall be tested by either radiographic or ultrasonic methods. As much work as possible shall be welded in shops and the layout and sequence of the operations shall be so arranged as to eliminate distortion and shrinkage stresses to the satisfaction of the Engineer.

##### - Plant and equipment

The plant used shall be of sufficient capacity to suit the welding procedure laid down and be capable of depositing the particular type or types of electrodes to be used under the conditions of current and voltage specified by the electrode manufacturer. The number of welding sets, both automatic and hand operated proposed to be used in the work shop for fabrication of the structural steel work for the contract shall be given by the Bidder along with his tender. Efficient means shall be provided for the accurate indication of the current and in addition, a pair of tong testers shall be supplied by the Contractor and be available to the Engineer.

All equipment, accessories and connections shall be maintained in proper working order.

##### - Electrodes

All electrodes shall be kept under dry conditions. Any electrode damaged by moisture shall not be used unless it is stated by the manufacturer that when it is properly dried, there will be no detrimental effect. Any electrode which has part of its flux coating broken away or is otherwise damaged, shall be discarded. Any electrode older than 6 months from the date

of manufacture shall not be used. Low hydrogen electrodes shall be used for joints in material above 20 mm thick and all important connections.

- **Preparation of Material**

Surface to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign material except that mill scale which withstands vigorous wire brushing may remain. Joint surfaces shall, be free from fins and tears. Preparation of edges by gas-cutting shall, wherever practicable, be done by a mechanically guided torch.

- **Welding procedure**

Before commencement of work the contractor shall submit to the Engineer for his approval, the procedure proposed to be adopted. The welding procedure shall be arranged to suit the details of the joints as indicated on the drawings and the position at which welding has to be carried out. Welding procedure shall cover the following:

- i) Type and size of electrodes
- ii) Current and (for automatic welding) arc voltage
- iii) Length of run per electrodes, or (for automatic welding) speed of travel
- iv) Number and arrangement of runs in multi-run welds

When necessary the procedure shall also cover the following:

- v) Position of welding
- vi) Preparation and set up of parts
- vii) Welding sequence
- viii) Pre or post heating
- ix) Any other relevant information

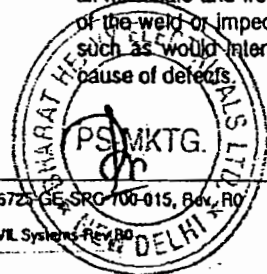
- The welding procedure shall be so arranged that the distortion and shrinkage stresses are reduced to a minimum and that the welds meet the requirement of quality specified here under.

- The Contractor shall record the approved welding procedure and shall provide each operator with all relevant details. Alternative approved procedure may be furnished in such cases when it is desirable to make the fullest use of available plant. The welding procedure then laid down shall be strictly followed and no variation shall be permitted without the approval of the Engineer.

- Preening of the welds involving deformation of the weld surface either during deslagging operation or thereafter, shall not be allowed.

Fusion faces and surrounding surfaces:

- Fusion faces and the surrounding surfaces within 50 mm of welds shall be free from all mill scale and free from oil, paint, or any substance which might affect the quality of the weld or impede the progress of welding. They shall be free from irregularities such as would interfere with the deposition of the specified size of weld or be the cause of defects.



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- All mill scale within 50 mm of welds shall be removed prior to welding either by pickling at works followed by thorough power wire brushing or by other approved methods.
- If preparation or cutting of the fusion faces is necessary the same shall be carried out by shearing, chipping, gas-cutting or flame-gouging.
- Where hand gas cutting or hand-gouging is employed, the blow pipe or gouging blow pipe shall be properly guided.
- Assembly for welding:

Parts to be welded shall be properly assembled and held firmly in position by means of jigs and clamps prior to and during welding.

The fit of joints at contact surfaces which are not completely sealed by welds, shall be close enough to exclude water after painting. Abutting parts to be butt-welded shall be carefully aligned. Misalignments greater than 3 mm or 25% of the thickness of thinner plate whichever is smaller shall be corrected and in making the correction the parts shall not be drawn into a sharper slope than two degrees (2 deg).

The work shall be positioned for flat welding whenever practicable.

#### - Welding Sequence

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as will avoid needless distortion and minimise shrinkage stresses. Where it is impossible to avoid high residual stresses in the closing welds of a rigid assembly, such closing welds shall be made in compression elements.

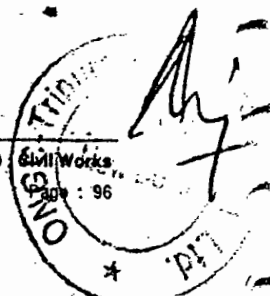
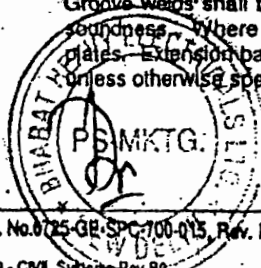
In the fabrication of cover-plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the member. Long girders or girder sections may be made by shop splicing not more than three sub-sections, each made in accordance with this paragraph.

When required by the 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.

#### - Welding technique

All complete penetration groove welds made by manual welding, except when produced with the aid of backing material not more than 8 mm thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged out on the back side before welding is started from that side, and shall be so welded as to secure sound metal and compact fusion throughout the entire cross-section. Groove welds made with the use of a backing of the same material as the base metal shall have the weld metal thoroughly fused with the backing material. Backing strips need not be removed. If required, they may be removed by gouging or gas cutting after welding is completed, provided no injury is done to the base metal and weld metal and the weld metal surface is left flush or slightly convex with full throat thickness.

Groove welds shall be terminated at the ends of a joint in a manner that will ensure their soundness. Where possible, this should be done by use of extension bars or run-off plates. Extension bars or run-off plates need not be removed upon completion of the weld unless otherwise specified elsewhere in the specifications.



The effective area of fillet welds shall be considered as the effective length times the effective throat thickness. The effective length of fillet welds except fillet welds in holes and slots shall be the overall length of full size fillet, including returns.

The effective throat thickness of a fillet weld shall be the shortest distance from the root to the face of the diagrammatic weld.

The minimum size of weld is determined by the thicker of the two parts joined except that the weld size need not exceed the thickness of the thinner part joined unless a larger size is required by calculated stress. For this exception, particular care shall be taken to provide sufficient preheat for soundness of the weld. The minimum size of fillet welds are as follows.

Material thickness of thicker part joined	Minimum size of fillet weld	Minimum effective throat thickness of partial penetration groove welds
Upto 6 mm	3 mm	3 mm
6mm to 12 mm	5 mm	5 mm
12 mm to 19 mm	6 mm	6 mm
19 mm to 38 mm	8 mm	8 mm
38 mm to 57 mm	8 mm	10 mm
57 mm to 152 mm	8 mm	13 mm
Over 152 mm	8 mm	16 mm

The minimum effective length of a fillet weld designed on the basis of strength shall not be less than 4 times the nominal size (of weld) or else the size of the weld shall be considered not to exceed 1/4 of the effective length.

In intermittent welds the effective length of any segment of intermittent fillet welding shall be not less than 4 times the weld size with a minimum of 40 mm.

The minimum amount of lap on lap joints shall be 5 times the thickness of the thinner part joined but not less than 25 mm.

Side or end fillet welds terminating at ends or sides respectively of parts or members shall wherever practicable, be returned continuously around the corner for a distance not less than 2 times the nominal size of weld.

To get the best and consistent quality of welding, automatic submerged arc process shall be preferred. The technique of welding employed, the appearance and quality of welds made, and the methods of correcting defective work shall all conform to the relevant Indian Standards.

Preheating techniques combined with the use of low hydrogen electrodes shall be used for

- i. Certain joint configurations as specified in the drawings and as directed by the Engineer.
  - ii. Welding involving plates over 20 mm thickness conforming to IS:2062.
- Temperature

No welding shall normally be done on parent material at a temperature below (-) 5 deg C. However, if welding is to be undertaken at low temperatures, adequate precautions as recommended in relevant Indian Standard shall be taken. When the parent material is less than 40 mm thick and the temperature is between (-) 5 deg C and 0 deg C, the

surface around the joint to a distance of 100 mm or 4 times the thickness of the material, whichever is greater, shall be pre-heated till it is handwarm. When the parent material is more than 40 mm thick, the temperature of the area mentioned above shall in no case be less than 20 deg C. All requirements regarding preheating of the parent material shall be in accordance with the relevant Indian Standard.

The table below may be used as a guideline for preheat and interpass temperature to be maintained within 75 mm on either side of the point of welding.

Thickness of the thickest part at the point of welding other than low hydrogen welding electrodes	Minimum preheat & Interpass temperature	
		Low hydrogen welding electrodes
Upto 20 mm	None	None
20 mm to 40 mm	65°C	20°C
40 mm to 63 mm	110°C	65°C
Over 63 mm	150°C	110°C

- Accuracy of fit up:

Parts to be fillet welded shall be brought into as close contact as practicable and the gap due to faulty workmanship or incorrect fit up shall not exceed 1.5 mm. If greater separation occurs at any position, the size of fillet weld shall be increased at such positions by the amount of the gap.

- Jigs and manipulators:

Jigs and manipulators shall be used where practicable and shall be designed to facilitate welding and to ensure that all welds are easily accessible to the operators.

- End of butt welded joints:

The ends of butt joints shall be welded so as to provide the full throat thickness. This may be done by the use of extension pieces, cross-runs or other means approved by the Engineer.

- Weld face and reinforcement of butt welds:

The weld face shall at all places be deposited proud of the surface of the parent metal. Where a flush surface is required the surplus metal shall be dressed off.

- Minimum leg length and throat thickness in fillet welds:

The minimum leg length of a fillet weld as deposited shall be not less than specified size. In no cases shall a concave weld be deposited without specific permission of the Engineer. Where permitted, the leg length shall be increased above that specified, so that the resultant throat thickness is as great as would have been obtained by the deposition of a flat-faced weld of the specified leg length.

- Deslagging:

After making each run of welding all slag shall be thoroughly removed.

- Quality of welds:

The weld metal, as deposited (including tack welds if to be incorporated) shall be free from cracks, slag inclusions, gross porosity, cavities and other deposition faults. The weld metal shall be properly fused with the parent metal without serious undercutting or overlapping at the toes of the weld. The surface of the weld shall have a uniform consistent contour and regular appearance.

- Working conditions:

Welding shall not be done under weather or other conditions which might adversely affect the efficiency of the welding and where necessary effective protection or other safeguard shall be provided.

- Qualification and testing of welders:

The Contractor shall satisfy the Engineer that the welding operators are suitable for the work upon which they will be employed and shall produce evidence to the effect that welders have satisfactorily completed appropriate tests as described in IS:817. The Engineer may at his discretion order periodic tests of the welders and/ or of the welds produced by them. Such tests shall be at the expense of the Contractor.

- Supervision:

The Contractor shall employ a competent welding supervisor or charge-hand to ensure that the standard of workmanship and the quality of the materials comply with the requirements laid down in this specification.

**Machining of butts, caps and bases**

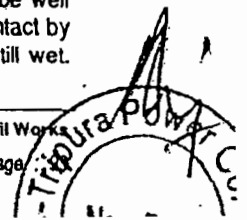
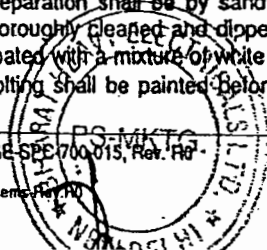
Column splices and butt joints of struts and compression members depending on contact for stress transmission shall be accurately machined and close butted over the whole section with a clearance not exceeding 0.2 mm locally. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc. after rivetting, **bolting and/ or welding together as the case may be, should be accurately machined** so that the parts connected butt over the entire surfaces of contact. **Care should be taken that those connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 2.0 mm.**

Where sufficient gussets and bolts or welds are provided to transmit the entire loading or where connection is by full penetration butt welds, the column ends need not be machined.

Slab bases and caps, if applicable, shall be in one solid piece, and except when cut from material with surfaces, and shall be accurately machined over the bearing surfaces and shall be in effective contact over the whole area of the machined end of the stanchion. A bearing face need not be machined if it is to be grouted directly to a foundation provided it is true and parallel to the machined face. To facilitate grouting, holes shall be provided where necessary in stanchion bases for escape of air.

**Shop painting**

The whole of steel work with the exception of bolts and nuts and machined surfaces after being thoroughly cleaned to remove rust, loose scale, grease, dust etc. shall be given one shop coat of primer compatible with the finish paint. For epoxy based paints, surface preparation shall be by sand blasting. All rivets, bolts, nuts and washers etc. shall be thoroughly cleaned and dipped in boiled linseed oil. All machined surfaces shall be well coated with a mixture of white lead and tallow. Surfaces which are to be held in contact by bolting shall be painted before assembly, and the parts brought together while still wet.



Unless specified otherwise, all surfaces inaccessible after bolting or intermittent welding shall be given two coats of approved paint before assembly. In the case of surfaces to be welded, the steel shall not be painted or metal coated within a suitable distance of any edges to be welded if the paint specified or the metal coating would be harmful to welders or impair the quality of the welds. Welds and adjacent parent metal shall not be painted prior to deslagging, inspection and approval. Parts which are to be encased in concrete shall not be painted or oiled.

#### Marking, packing and despatching

Each piece shall be distinctly marked before delivery, in accordance with an approved marking diagram and shall bear such other marks as will facilitate erection. For easy identification at site, a small distinguishing mark for each building shall be painted on each end of every member before despatch from fabrication shop. The fabricated steel work shall be despatched in such portions as may be found convenient for erection or as ordered by the Engineer.

All projecting plates or bars and all ends of members at joints shall be stiffened, all straight bars and plates shall be bundled, all screwed ends and machined surfaces shall be suitably packed and all rivets, bolts, nuts, washers and small loose parts shall be packed separately in cases so as to prevent damage or distortion during transit.

#### 9.5.8.6 Erection

##### General

The material shall be verified with marking on the marking plan or shipping lists which shall be supplied by the Contractor.

Any material found damaged or defective shall be stacked separately and the damaged or defective portions be painted in distinct colour. Such material is to be dealt with under the orders of the Engineer without delay.

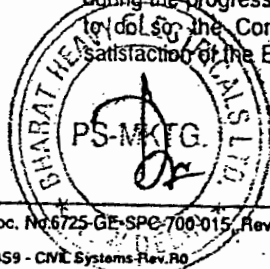
The field assembling of the component parts of a structure shall involve the use of method and appliances not likely to produce injury by twisting, bending or otherwise deforming the metal. No member slightly bent or twisted shall be put in place until the defects are corrected and members seriously damaged in handling shall be rejected.

All small bends or twists received by members shall be rectified before such members are put in place; any serious bends or damage shall be reported at once to the Engineer by the Contractor for instructions. The straightening of bent edges of plates, angles and other shapes shall be done by methods not likely to produce fracture or other injury.

Following the completion of the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of incipient or other fractures.

##### Setting Out

The Contractor shall assume full responsibility for the correct setting out of all steel work and erecting it correctly as per alignment and levels shown on the drawings and plumbing of vertical members. Datum points will be fixed by the Engineer near the work site. Notwithstanding any assistance rendered to the Contractor by the Engineer, if at any time during the progress of the work any error should appear to arise therein, on being required to do so, the Contractor at his own cost shall remove and amend the work to the satisfaction of the Engineer.



**Field connections**

All field connections in the trusses, columns, girders, framework etc. shall be welded, unless otherwise specified. Connection of purlins, girts and other unimportant members only may be bolted with black bolts, except where welded connections are required.

Use of "high strength friction grip" bolts in place of welding may be permitted for field connections at the discretion of the Engineer.

**Field bolting**

All relevant portions in respect of bolted construction of the Specification for Fabrication of Structural Steel work shall also be applicable for field bolting in addition to the following.

Bolts shall be inserted in such a way so that they may remain in position under gravity even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled, all joint surfaces, including those adjacent to the washers, shall be free of scales except tight mill scales. They shall be free of dirt, loose scales, burns, and other defects that would prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil, paint, lacquer, or galvanising.

All high tensile bolts shall be tightened to provide, when all fasteners in the joint are tight, the required minimum tension by any of the following methods.

**a) Turn-of-nut method**

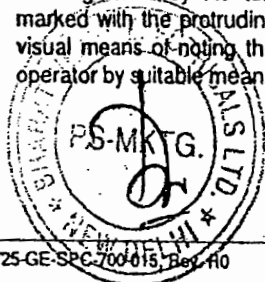
When the turn-of-nut method is used to provide the bolt tension, there shall first be enough bolts brought to a "snug tight" condition to ensure that the parts of the joint are brought into good contact with each other. "Snug tight" is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Following this initial operation, bolts shall be placed in remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable amount of nut rotation specified in Table I with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation, there shall be no rotation of the part not turned by the wrench.

**TABLE-I**

Bolt length exceeding 8 times diameter or 200 mm	Remark
2/3 turn	Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. Tolerance on rotation- 30° over or under

Bolts may be installed without hardened washers when tightening is done by the turn-of-nut method.

Bolts-tightened by the turn-of-nut method may have the outer face of the nut match-marked with the protruding bolt point before final tightening, thus affording the inspector visual means of noting the actual nut rotation. Such marks can be made by the wrench operator by suitable means after the bolts have been brought up snug tight.



**Torque wrench tightening**

When torque wrenches are used to provide the bolt tensions, the bolts shall be tightened to the torques specified in Table-II. Nuts shall be in tightening motion when torque is measured. When using torque wrenches to install several bolts in a single joint, the wrench shall be returned to "touch up" bolts previously tightened, which may have been loosened by the tightening of subsequent bolts, until all are tightened to the required tension.

TABLE-II

Nominal Bolt Diameter (mm)	Torque to be applied (Kg.M) for Bolt class 8.8 of IS:1367
20	56.93
22	81.63
24	103.73

In either case of the above two methods if required, because of bolt entering and wrench operation clearances, tightening may be done by turning the bolt while the nut is prevented from rotating.

Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately ten seconds.

Holes for turned bolts to be inserted in the field shall be reamed in the field. All drilling and reaming for turned bolts shall be done only after the parts to be connected are assembled.

Tolerances applicable in the fit of the bolts shall be in accordance with relevant Indian Standard Specifications. All other requirements regarding assembly and bolt tightening shall be in accordance with this Sub-Clause.

**Field welding**

All field assembly and welding shall be executed in accordance with the requirements for shop fabrication, excepting such as manifestly apply to shop conditions only. Where the steel has been delivered painted, the paint shall be removed before field welding, for a distance of at least 50 mm on either side of the joints.

**Bedding and grouting**

Bedding shall be carried out with cement grout or mortar having a compressive strength of 250 kg per sq. cm at 28 days for main column bases and 200 kg per sq. cm at 28 days for secondary column bases. For the main column the Contractor shall provide screed bars of mild steel flats and fix them in mortar. The Engineer will be the sole authority in deciding "main" and "secondary" columns and his decision in this matter will be binding on the Contractor within the terms of this contract.

The bedding shall not be carried out until a sufficient number of columns has been properly aligned, levelled and plumbed and sufficient girders, beams, trusses and bracings are in position to the satisfaction of the Engineer.

Immediately before grouting, the space under the base plate and around bolts shall be thoroughly cleaned and made free from excessive moisture.

The grout or mortar shall be mixed as thick as possible consistent with fluidity and shall be poured under pressure with pressure grouting machine, until the space has been filled with mortar. Admixtures, if directed to be added will be measured and paid separately. If desired, ready mix high strength non-shrink grout of specified strength shall be used.

#### Painting after erection

Before painting of steel which is delivered unpainted is commenced, all surfaces to be painted shall be dry and thoroughly cleaned of all loose scale, rust, dust, grease, etc.

The specified protective treatment shall be completed after erection. All rivet and bolt heads and the site welds after deslagging shall be cleaned. Damaged or deteriorated paint surfaces shall be made good first with the same type of paint as the shop coat. Where specified, surfaces which will be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet.

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

Site painting should not be done in frosty or foggy weather or when humidity is such as to cause condensation on the surface to be painted.

Two or more final coats of approved paint as specified shall be applied to the steel work after erection.

#### Correction of misfits

Correction of minor misfits, a reasonable amount of reaming and cutting of excess-stock from rivets will be considered a legitimate part of the erection.

Any error in shop work which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or a moderate use of reaming and slight chipping or cutting shall immediately be reported to the Engineer and his approval of the method of correction obtained.

#### 9.5.8.7 Testing and Acceptance Criteria

##### General

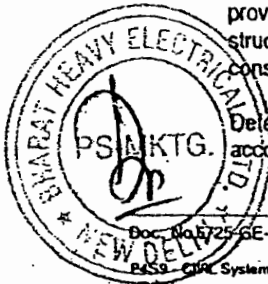
The Engineer shall have free access at all reasonable times to those parts of the manufacturer's works which are concerned with fabrication of the steel work and shall be afforded all reasonable facilities for satisfying himself that the fabrication is being undertaken in accordance with the provisions of this specification.

Unless specified otherwise, inspection shall be made at the place of manufacture prior to despatch and shall be conducted so as not to interfere unnecessarily with the operation of the work.

Tolerance for fabricated structures shall be as per IS:7215.

Should any structure or part of a structure be found not to comply with any of the provisions of this specifications, it shall be liable to rejection. No structure or part of the structure, once rejected shall be resubmitted for test, except in cases where the Engineer considers the defect as rectifiable.

Defects which may appear during fabrication shall be made good with the consent of and according to the procedure laid down by the Engineer.



All gauges and templates necessary to satisfy the Engineer shall be supplied by the manufacturer.

The Engineer may, at his discretion, check the test results obtained at the manufacturer's works by independent tests at the Government Test House or elsewhere.

When all tests to be performed in the Contractor's shop under the terms of this Contract have been successfully carried out, the steel work will be accepted forthwith and the Engineer will issue an acceptance certificate, upon receipt of which, the items will be shop painted, packed and despatched. No item is to be delivered unless an acceptance certificate for the same has been issued. The satisfactory completion of these tests or the issue of the certificates shall not bind the Owner to accept the work, should it, on further tests before or after erection, be found not in compliance with the Contract.

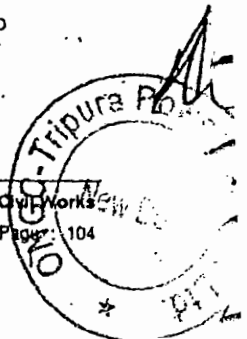
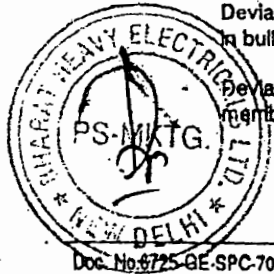
#### Tolerances

##### - Fabrication

Tolerances for fabrication of structures shall be generally as per IS:7215.

In particular the acceptable fabrication tolerances for various parameters are given below:

- Length
- Length of strut finished for tight bearing contact : (±) 1 mm
- Length of any other member upto and including 12 m : (+) 0, (-)3.0 mm
- Length of any other member over 12 m : (+) 0, (-)0.00025 L subject to a max. of (-)5.0 mm
- Width
- Width of built-up girders (plate girders) : (±) 3 mm
- Deviation in the width of members required to be inserted in other member : (+) 0, (-)2 mm
- Depth
- Depth of girders (measured at centreline of web) for depths upto 4 m : (+) 3, (-)2 mm
- do- for depths over 4 m : (+) 4, (-)3 mm
- Sweep, Camber
- Deviation from straightness in plan (Sweep) : 0.001 L subject to max. of 10 mm
- Deviation in elevation convexity (Camber) : (+) 5 mm, (-) 0
- Deviation of centreline of web from centreline of flanges in built-up members at contact surfaces : 3 mm
- Deviation from flatness of plate webs of built-up members in a length equal to the depth of the member : 0.005 d subject to max. of 10 mm



**Tilt of flange of plate girders**

- at splices & stiffeners, at supports, at the top flanges of crane girders, at bearings : 0.005 b subject to max. of 2 m
- at other places : 0.015 b subject to max. of 4 mm
- Deviation from squareness of flange to web of box columns and box girders : (±) 3 mm
- Deviation from squareness of fixed base plates to axis of column. This dimension shall be measured parallel to the longitudinal axis of the column at points where the outer surfaces of the column sections make contact with the base plate
- Deviation from squareness of machined ends to axes of columns : 0.5 mm
- Deviation from squareness of machined ends to axes of beam or girder : 0.6 mm

In addition to the above tolerances, the fabrication of crane girders shall comply with the following:

- Top flanges shall be as flat as possible and the cross camber over the central width of 150 mm shall not exceed 0.6 mm with the convex surface upwards. Crane girder with a concave surface over the central width of 150 mm will not be accepted.
- Webs will be flat and straight and shall not vary from the intended line by more than 2 mm measured at the top flange.
- Gantry girders shall be straight with SWEEP not exceeding 3 mm in 12 m length of the girder. CAMBER shall not exceed 3 mm in 12 m length.
- The tolerance on the overall depth of crane girders without their bearings shall be (±) 2 mm.

**Acceptance**

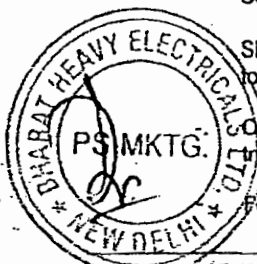
Should any structure or part of a structure be found not to comply with any of the provisions of this specification, the same shall be liable to rejection. No structure or part of the structure, once rejected, shall be offered again for test, except in cases where the Engineer considers the defects rectifiable. The Engineer may, at his discretion, check the test results obtained at the Contractor's works by independent tests at an approved laboratory.

**Erection**

- Columns

Shifting of column axis at foundation with respect to building both in longitudinal & lateral direction : (±) 3 mm

Out of plumbness (verticality) of column axis from true vertical axis as measured at column top  
For column upto 10 m height : (±) 5 mm



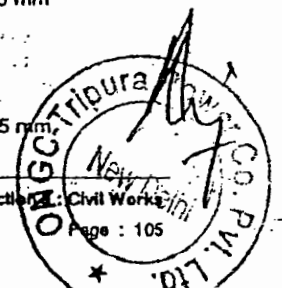
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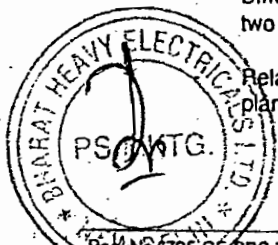
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- For column exceeding 10 m 10 m height	:	(±) 1/2000 of column height but not more than 15 mm
- Deviation in the level of bearing surface of columns at foundation top with respect to true level	:	(±) 3 mm
- Deviation in bearing levels for beams, trusses . etc. with respect to true level	:	(±) 3 mm
- Difference in bearing level between adjacent column both across and along the building	:	(±) 6 mm
- Difference in erected position at adjacent pairs of columns along the length or across the width of building prior to connecting trusses/beams with respect to true distance	:	(±) 10 mm
- Trusses/Beams		
- Deviation at Centre of span of upper chord member from vertical plane running through chord and perpendicular to plane at truss/beams	:	1/250 of depth of truss or of 20 mm which- ever is less
- Lateral displacement of top chord at centre of span from vertical plane running through centre of supports	:	1/1500 of the span or 10 mm whichever is less
- Lateral shift in location from its true line of purlin/beam	:	(±) 5 mm
- Crane Girders & Rails		
- Difference in levels of crane girder/crane rails measured between adjacent columns	:	5 mm
- Difference in levels of crane rails (across the building)		
- Over the supports	:	10 mm
- At the mid span of girders	:	15 mm
- Difference in level of flange of successive girders at connection	:	1 mm
- Deviation in the crane rail level at any point from true level	:	(±) 5 mm
- Difference in crane rail actual levels between any two points 2 m apart along the rail length	:	2 mm
- Relative shift of crane rail surfaces at a joint in plan and elevation	:	2 mm subject to grinding of Surfaces for Smooth transition



- Relative shift in the location of crane stops (end buffers) along the crane tracks	:	1/1000 of track gauge to a max. of 20 mm
- Deviations of crane rail axis from centerline of web	:	(±) 3.5 mm
- Deviations in alignment of crane rail in plan measured between any two points 2 m apart	:	1 mm
- Deviation in crane rail gauge	:	5 mm

**9.5.9 Brickwork & Plastering****9.5.9.1 Scope**

This specification covers the requirements in respect of materials, workmanship and quality for brickwork and plastering.

**9.5.9.2 Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Indian Standards Institution and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

**Brick work**

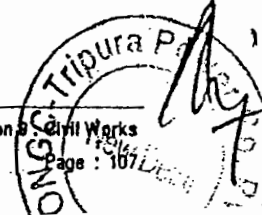
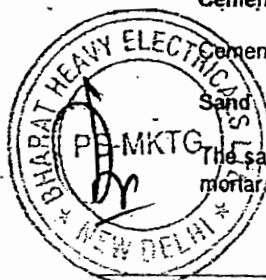
IS:1077	Common burnt clay building bricks
IS:1542	Sand for plaster
IS:1661	Code of practice for application of cement and cement-lime plaster finishes
IS:2166	Sand for masonry mortars
IS:2212	Code of practice for brickwork
IS:2250	Code of practice for preparation and use of masonry mortars
IS:2691	Burnt clay facing bricks
IS:3495	Methods of tests of burnt clay building bricks
IS:3696	Safety code for scaffolds and ladders
IS:5454	Methods of sampling of clay building bricks

**9.5.9.3 Materials****Cement**

Cement used shall conform to IS:269.

**Sand**

The sand shall be approved river or pit sand and it shall conform to IS:2116 for masonry mortar and to IS:1542 for plaster mortar.



**Bricks**

The bricks used shall be atleast chamber burnt second class (class B) bricks conforming to IS:1077 having a minimum compressive strength of 35 kg/cm<sup>2</sup>. Bricks are to be whole, uniform texture, sound, well burnt, free from cracks, square and well shaped, uniform in size, uniform red cherry or copper colour and shall emit a clear ringing sound when struck. Slight distortion or rounded edges are permitted provided no difficulty arises during laying of uniform course.

Water absorption after 24 hours immersion shall not exceed 20% by weight. Dimensional tolerance shall not exceed 8%. Laboratory test has to be conducted to ascertain the same. Representative samples shall be submitted and approved samples shall be retained by the Engineer for future comparison.

**9.5.9.4 Storage and Handling**

Bricks shall not be dumped at site. These shall be stacked in regular tiers on firm ground, even as these are unloaded, to minimize breakage and defacement of bricks. Bricks selected from different situation of use in the work shall be stacked separately. The broken bricks shall not be used in the masonry and shall be separated from the lot being used for masonry works.

**9.5.9.5 Workmanship****Brick work**

The whole of the brickwork shall be carried out by the Contractor in a uniform manner.

All the bricks shall be kept under water till they are completely soaked and used on the works on their becoming skin dry.

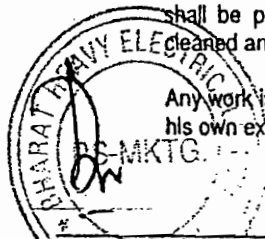
The Contractor shall set out and build all brickwork to the dimension, thickness and heights shown on the drawings. The Contractor shall build all brickwork in English bond and half brick walls and casing to pipe, chases etc in stretcher bond. Brickbats shall not be used except where required for bond.

The Contractor shall lay bricks in full mortar beds with shoved joints. The joints are not to exceed 10 mm in thickness and are to be full of mortar, close, well finished and neatly struck. The vertical joints in any course shall not be nearer than quarter of a brick length from those in the course below. All joints shall be of same width except for small variations to maintain bond. The brickwork shall be laid plumb and trim to line and level. No portion of brickwork shall be raised more than 1 metre above another at one time. If the mortar in any course has begun to set, the joints shall be raked out before another course is laid. The top course of brickwork in reinforced concrete framed structure shall be wedged against reinforced concrete surface and joint well filled with mortar.

The Contractor shall flush up thoroughly with mortar all joints as the work proceeds. Where brickwork is to receive plaster, the joints shall be raked to a depth of 12 mm to provide proper bond.

The brickwork as it progresses shall be thoroughly watered on its faces and top. New work shall be properly bonded with the old work. The surface of unfinished work shall be cleaned and thoroughly wetted before joining new work to it.

Any work in which the mortar perishes shall be dismantled and rebuilt by the Contractor at his own expense.



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The Contractor shall carry out work in as clean a manner as possible and shall remove excess material and mortar droppings daily.

Where brick walls, are to receive plaster, excess materials and mortar droppings shall be removed and the surface shall be brushed clean.

During cleaning operations, adjacent work shall be protected and any damage resulting from improper protection shall be made good by the Contractor at his own cost.

Reinforcement if shown in the drawing shall be provided fully embedding in mortar after thoroughly cleaned. These shall be lapped with dowels if left in RC columns or welded to steel columns.

Encasing of structural steel shall be done by building masonry work round flanges, webs etc., and filling the gap between steel and masonry by minimum 12 mm thick mortar. Encased members shall be wrapped with chicken wire mesh when shown on drawings or instructed by the engineer. The minimum lap in chicken wire mesh shall be 50 mm. Other steel embeddings shall be generally embedded in mortar and masonry unit shall be cut as required.

#### Plastering

Unless otherwise specified, all plaster work shall be carried out according to IS:1661. The thickness and proportion of cement plaster shall be as specified in the drawing.

The surface to be plastered shall be cleaned of all extraneous matter and rubbish. In brickwork the joints shall be raked and concrete surface roughened by chipping or hacking. Any shuttering material adhering to the concrete shall be removed. The Contractor shall make plaster pads of the required thickness of plaster for correctness of plumb, line and level. The surface shall be thoroughly watered and soaked and aerated and all holes shall be closed before starting plastering operation.

Plaster, when more than 15 mm thick shall be applied in two coats - a base coat followed by the finishing coat. Thickness of under coat shall be of sufficient to fill up all unevenness in the surface, no single coat, however, shall exceed 15 mm in thickness.

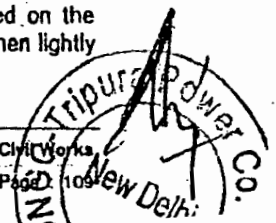
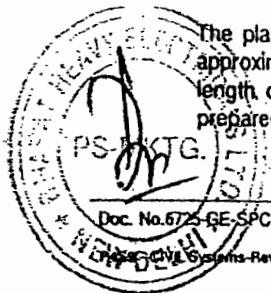
For one coat plaster work, the plaster shall be laid slightly thicker than the specified thickness and the surface then levelled with flat wooden rule to the required thickness. The plaster shall be well pressed into the joints and the surface finished as specified.

For two coats of plaster work, the first coat shall be applied as described above except that the surface shall be left rough and keys formed for the application of second coat. The second coat shall be applied a day or two after the first coat has set, but the first coat shall not be allowed to dry. The second coat shall consist of mortar ground very fine and shall be laid on with a wooden rule to a specified thickness, rubbed smooth and levelled and the surface plastered completely the same day. The levelling shall be continued till the plaster is quite dry and all moisture which exudes from the plaster shall be wiped off with a fine cloth. The surface shall be kept dry until exudation of moisture ceases, during the process of rubbing.

#### Finish

- Sand faced plaster

The plaster shall be applied in two coats. The first coat or the scratch coat should be approximately 14 mm and shall be continuously carried out without breaks to the full length of wall or upto doors, windows etc. The scratch coat shall be dashed on the prepared surface with heavy pressure, brought to true and even surface and then lightly



roughened by cross scratch lines to provide bond for finish coat. The scratch coat shall be cured for atleast 7 days and then allowed to dry.

The second coat shall be 6 mm thick and it shall not be applied until atleast 10 days have elapsed after the application at second coat. Before application of the second coat, the scratch coat shall be evenly damped. This coat shall be applied from top to bottom in one operation and without joints, finish shall be straight, true and even. Only approved river sand shall be used for the second coat and for finishing work. Sand for finish shall be of even coarse size and shall be dashed on the surface and sponged.

#### - Plaster-of-Paris Punning

Plastered surfaces, where specified, shall be finished with plaster-of-paris punning. The thickness of punning shall be 2 mm and shall be applied by skilled workman. The finish shall be smooth, even and free from undulation. Before bulk work is taken in hand, a sample of punning shall be done on roughly 1 sq.m area and approval of the Engineer-in-charge taken. The work shall be taken then in hand as per approved sample.

#### Curing

The brick shall be cured for a period of fourteen (14) days after laying and the plaster shall be cured for a period of seven (7) days.

#### Expansion & Separation Joints

Location and details of expansion joints shall be strictly as shown in the drawings. Expansion joint filler boards and sealing strips shall have minimum transverse joints. Transverse joints shall be approved by the Engineer.

Separation joints shall be with standard water proof paper or with alkathene sheets about 1 mm in thickness. Length and sealing of laps shall be to the satisfaction of the Engineer.

#### Damp Proof Course

The proportion of cement to aggregates shall be 1:2:4 using 6 mm down stone chips with a water proofing admixture. The percentage of waterproof admixture shall be as per manufacturer's specification but not less than 1% by weight of cement. The brick masonry surface shall be leveled, flushed up and prepared as directed to receive the damp-proof course. The thickness of damp proof course shall be 40 mm. In masonry walls of buildings it shall normally be placed above the external ground level. It shall be laid for the full width of the wall. The top surface shall be kept rough or ribbed for mortar for brickwork coming over it, for proper adhesion. All exposed surfaces of the damp-proof course shall be finished fair and smooth. It shall be cured for at least 7 days. After the surface has partially set, hot bitumen shall be applied in two coats at the rate of 1.7 kg per sq.m per coat and dry sand spread over it.

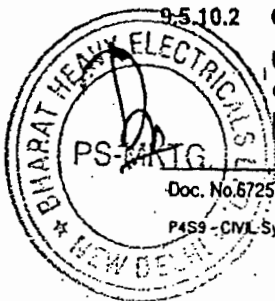
#### 9.5.10 Sheeting Work In Roof and Siding

##### 9.5.10.1 Scope

This specification covers the requirements in respect of materials, workmanship and quality for sheeting work in Roof and Siding of Buildings.

##### 9.5.10.2 Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of design,



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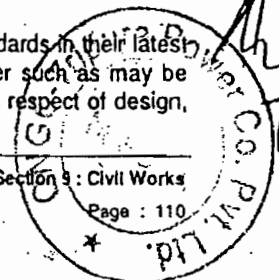
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workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

- IS : 277 Galvanised steel sheets.
- IS : 730 Hook bolts for corrugated sheet roofing.
- IS : 2096 Asbestos cement flat sheets.
- IS : 5119 Laying and finishing sloped roof coverings.
- IS:1726 Sheet metal rain water pipes.
- IS : 8869 Washers for corrugated sheet roofing.
- IS :12866 Fibre glass reinforced plastic sheets.

#### 9.5.10.3 Materials

Roof and Side sheeting shall generally be of the following types of materials.

- a) Aluminium Sheet (AL)
- b) Galvanised Iron (GI)/Galvanised Steel (GS)
- c) Fibre Glass Reinforced Plastic (FRP)
- d) Colour Coated steel sheets

Aluminium Sheet (AL)

Aluminium sheets and accessories shall be of INDAL (Indian Aluminium Company) brand or approved equivalent.

Aluminium roofing and siding shall be of the following types as indicated in the drawings.

- a) Corrugated
- b) Troughed

Aluminium sheets shall be 0.71 mm and 0.56 mm thick for roof and side sheeting respectively unless otherwise specified.

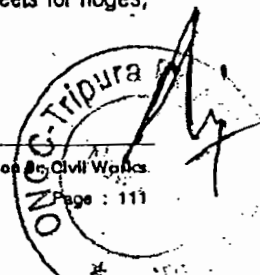
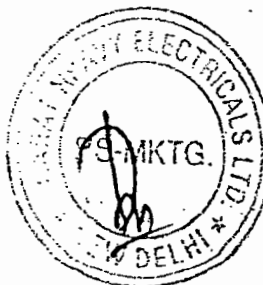
Flashing ridge etc. shall be of plain aluminium sheets.

Galvanized Iron/Steel Sheet (GI/GS)

Galvanised sheets shall be zinc coated cold rolled sheets, conforming to class 3 of IS 277 and of the following types.

- a) Corrugated
- b) Plain

Galvanised sheets shall be of 1 mm (20G) corrugated sheets for roofing, 0.8 mm (22G) corrugated sheets for side sheeting, flashing etc and 1 mm(20G) plain sheets for ridges, flashing gutters etc unless otherwise specified.



**Fibre-glass reinforced plastic sheets (FRP)**

Fibre glass reinforced plastic sheets shall conform to IS:12866 and shall be translucent or opaque as shown in drawing. These sheets shall be shatterproof and should not crack, chip or rot.

The sheets shall have uniform thickness, translucency (if specified) and strength. The sheets shall be of approved manufacture and shall match the roofing profiles.

Wherever necessary and as shown in the drawing, caulking shall be of non-hardening and non-staining type.

**Colour Coated Sheets****Permanent colour coated sandwiched insulated metal cladding system**

Troughed zinc - aluminium alloy coated (both sides) MS sheet having 0.6 mm minimum thickness (or high tensile steel sheet of 0.5 mm minimum thickness) shall be used on external face (outer face) of cladding system. Weight of coating shall not be less than 150 gm /sq.m. The outer side (exposed face) shall be permanently colour coated with Polyfluro Vinyl Coating (PVF2) of Dry Film Thickness (DFT) 20 microns (min) over primer. Inner side of external sheet shall be provided with suitable pre-coating of minimum 7 microns.

Galvanized MS sheets of minimum 0.6 mm thickness shall be used as inner liner (internal face) of cladding system. The exposed face shall be permanently colour coated with silicon modified polyester paint of DFT 20 microns (min) over primer.

Inner face of external sheet shall be provided with suitable pre-coating of minimum 7 microns. The rate of galvanization shall not be less than 150 gm /sq .m.

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

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

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

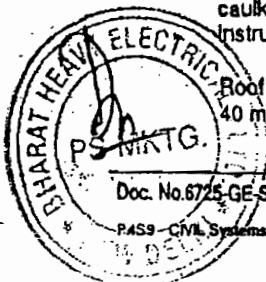
**Permanent colour coated (non-insulated) metal cladding system**

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

**General**

The Contractor shall also supply all necessary, special fittings, fasteners, flashings, caulking etc. required for installation of the sheets in strict accordance with manufacturer's instructions.

Roof & siding sheets shall be capable of withstanding 200 kg/sq.m wind loads. Wind tie of 40 mm x 6 mm GI flat shall be fixed at the two eaves end of the roof slopes. Fixing shall be



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done with the same bolts which secure sheets to the purlins: Slot holes shall be cut in the wind ties to allow for temperature variations.

#### 9.5.10.4 Installation

##### Aluminium Sheets

Aluminium sheets shall be fixed with aluminium fasteners along with aluminium curved/flat washers with bituminous felt, neoprene or rubber washers. Generally manufacturer recommendations shall be followed.

##### Galvanised Sheets

Galvanised sheets shall be fixed with minimum 150 mm and 100 mm end laps for roof and side sheets respectively, unless higher laps are specified by the manufacturer or in the drawings. Side laps shall be as per manufacturer's recommendations. Unless otherwise specified, 10 mm and 8 mm dia GI Hook/J Bolts shall be used for roof and side sheets respectively. 6 mm dia GI seam bolt and nut with GI round washer/limpet washer shall be used for stitching of roof sheets/fixtures and GI round washer/diamond washer for side sheets. There shall be at least three hook bolts at the ridges of corrugations in each sheet in every purlin and their spacing shall not exceed 300 mm. Seam bolts shall be placed zigzag on overlapping corrugations, with spacing not exceeding 600 mm in each staggered row. Ridge pieces shall be fabricated from 600 wide (girth) sheets with a radius of curvature of 50 mm unless specified. For fixing requirements not specified here, manufacturer's recommendations shall be adopted.

##### Colour Coated Sheets

Installation procedure and fixing details shall be generally in line with that for GI sheets. The sheets shall be fixed with J or L polymer coated bolts, polymer caps, seal washer and thrust washer. Spacing of bolts etc. shall be identical to GI sheets.

#### 9.5.10.5 Acceptance Criteria

The installation shall present a neat appearance and shall be checked for water-tightness. The following shall be checked.

- Side and end laps.
- Absence of holes or damages in sheet.
- Spacing of bolts.
- Provision of double washers.
- Proper installation of flashings, wind ties etc.

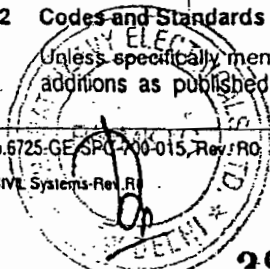
#### 9.5.11 Floor and Floor Finishes

##### 9.5.11.1 Scope

This specification covers requirements in respect of material, workmanship and quality for soling, concrete floor and floor finishes work.

##### 9.5.11.2 Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by Bureau of Indian Standards and all other such as may be



directed published by them during currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed here under:

IS:777	Specification for glazed earthenware wall tiles.
IS:2114	Code of practice for laying in situ terrazo floor finish
IS:2571	Codes of Practice for laying in-situ concrete flooring
IS:3461	Specification for PVC Asbestos floor tiles.
IS:3462	Specification for unbacked flexible PVC flooring.
IS:4457	Ceramic unglazed vitreous acid-resistant tiles
IS:5318	Code of practice for laying PVC flooring.
IS:5491	Code of practice for laying in-situ granolithic concrete floor topping

#### 9.5.11.3 Boulder Soling

The boulders for soling shall be granite, basalt or similar hard stone approved by the Engineer and generally shall be 230 mm thick. The sub grade shall be dressed to correct level and shall be rammed or rolled to proper consolidation before laying the soling. Stones shall be placed close to each other. The specified thickness shall be made up in one or more layers depending on thickness. The voids between the stones shall be hard packed first with smaller pieces and hammered into place so as to completely fill up the void along with murum as binding material and the layer is watered and is compacted by roller/mechanical compactor. In case of building enclosing heavy machinery like Gas turbine/Steam turbine, the compaction shall be by roller of 8/10 MT capacity.

#### 9.5.11.4 Cement Concrete Flooring

##### Materials

Requirements given in Section 10.4.5 shall be applicable.

##### Workmanship

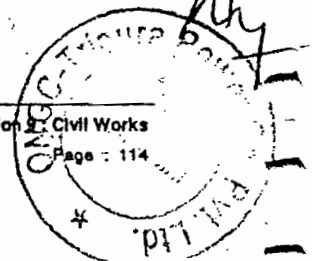
The workmanship shall generally conform to the specification for Plain & Reinforced concrete (Section 10.4.5) and also to IS:2571. For ground floor slab or paving in open area, where the slab has to be laid over a consolidated ground, soling, a kraft paper shall be spread over the area and kept moist before concreting.

The floor shall be laid in alternate panels, of size not exceeding 4 m to reduce risk of cracking, intermediate panels being filled in after two or three days. For paving in open area, contraction joint and expansion joints shall be provided as per IS specification. The expansion joints shall be filled with bitumen impregnated boards 25 mm thick of approved manufacturer and top 25 mm shall be covered with approved mastic sealing compound.

#### 9.5.11.5 Floor Finishes

Indian Patent Stone (IPS) with ironite topping

It shall consist of a under bed and a topping laid on an already laid and matured concrete base.



- **Thickness**

The total thickness of finish shall be 40 mm of which the topping shall be 12 mm. While the topping shall be uniform thickness the under bed may vary in thickness to provide necessary slopes.

- **Mix**

For underbed, it shall be 1:2:4 mix using 10 mm down graded stone chips. For toppings of heavy duty, the proportion of metallic hardener shall be strictly as specified by the manufacturer. In absence of such direction, one (1) part of metallic hardener shall be mixed dry with 4 parts of cement by volume. To this mixture, 6 mm nominal size stone chips shall be added in portion of 1:3 (mixture of hardener & cement : stone chips) by volume. Minimum quantity of water to be added to make it workable.

- **Laying**

The topping including the underbed shall be laid in alternate bays or in chequered board pattern. No panel shall be cast in contact with another already laid till the contraction of latter has already been taken place.

The maximum area of each panel shall be 3 sq.m of which no side shall be more than 2 m long.

A cement grout shall be applied and worked into the surface to receive the finish, the under bed then laid, compacted and levelled to proper grade with a screed or float. The topping shall be applied evenly on the underbed while it is not fully set, but firm enough and rolled and pressed to get full bond. The topping shall be troweled to a dense finish to the satisfaction of the Engineer. All trowel marks shall be mopped out with a cloth to give a clean smooth surface.

- **Curing**

After the surface is sufficiently set, the finished floor shall be kept moist for 7 days for curing.

Indian Patent Stone (IPS) with non-metallic surface hardener finish

It shall consist of an underbed and a topping on which the hardener shall be laid.

- **Thickness**

The total thickness of finish shall be 40 mm of which the topping shall be 12 mm including the hardener finish.

- **Mix**

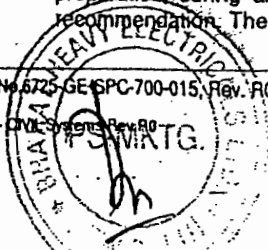
Mix for underbed and topping shall be same as for IPS flooring.

- **Hardener**

Hardener shall be non-metallic abrasion resistant surface hardener NITOFLOL HARDTOP or equivalent.

- **Laying**

The topping and underbed shall be laid as for IPS flooring. While the topping is still green, the hardener shall be applied by dry shake-on system. Cleaning of surface, surface preparation, curing and trowel finish shall be as per manufacturer's specifications and recommendation. The surface hardener application rate shall be as follows:



Heavy duty	:	7 kg/m <sup>2</sup>
Medium duty	:	5 kg/m <sup>2</sup>
Light duty	:	3 kg/m <sup>2</sup>

**Precast Terrazo Tile Finish**

It shall consist of manufactured terrazo tiles and an underbed.

**- Thickness**

The total thickness of finish including underbed shall be minimum 40 mm for floors and 30 mm for skirting. The skirting shall project 6 mm out from the adjacent wall finish. The necessary cutting into the surface receiving tile finish shall also be done.

**- Tiles**

The tiles shall be hydraulically pressed under strict quality control in a shop. The size of tiles shall be 250 x 250 x 20 mm unless otherwise specified. The topping of tiles shall not be less than 10 mm. Maximum tolerance allowance in length & breadth shall be ± 1 mm and the thickness ± 3 mm. All angles of tiles shall be right angles, all arises sharp and true, colour and texture of wearing face uniform throughout, and face shall be plane, free from pin holes and other blemishes.

The topping of tiles shall be composed of cement, (grey or white or mixture of two) colour pigment, marble dust and marble chips (chips size 3 to 20 mm) in such a proportion so as to produce the desired colour, texture & pattern approved by the Engineer.

The backings shall be composed of 1 part of ordinary grey cement, 1 1/2 part of sand and 3 parts of 6 mm down graded stone chips mixed with water. First grinding shall be given to the tiles at the shop before delivery. Tiles shall be packed properly to prevent damage during transit and storage. The tiles must be stored carefully to prevent staining of damp, rust, oil and grease or other chemicals.

**- Underbed**

The underbed for floor shall consist of a mix of 1 part cement, 1 1/2 parts coarse sand and 3 parts machine crushed 10 mm down stone chips by volume. For skirting, the mix shall consist of 1 part cement and 3 parts coarse sand. Only sufficient water to be added to give workable consistency.

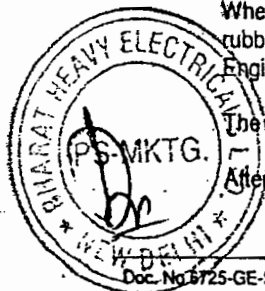
**- Laying**

The underbed mortar shall be evenly spread and brought to proper grade and consolidated. The surface shall be roughened for better bond. Before the underbed has time to set and while it is still fairly moist but firm, cement shall be hand dusted over it or a cement slurry applied and tiles shall immediately be placed upon and firmly pressed by wooden mallet onto the underbed until it achieves the desired level. The tiles shall be kept soaked for about 10 minutes just before laying. The joints between tiles shall be also as possible and not more than 1.5 mm wide.

When tiles are required to be cut to match the dimensions, these shall be sawn and edges rubbed smooth. The location of cut tiles shall be planned in advance and approval of the Engineer taken.

The floor tiles shall atleast enter 12 mm under the skirting tiles.

After fixing, the floor shall be kept moist and allowed to mature undisturbed for 14 days.



Aluminium or glass dividing strips shall be used for forming the panels.

- **Grinding and Polishing**

After sufficient curing, the surface shall be ground with fine grit blocks. It shall again be cleared with water, the slurry (mixture of cement & pigment) applied again to fill up any pinholes might have appeared and allowed to be cured again for five days. The surface is ground again with very fine grit blocks to get smooth surface without any pinhole. The grinding shall be done by a suitable machine. Where grinding machine cannot be used, hand grinding may be allowed. The choice of grit blocks at different stages of polishing shall be as per manufacturer's recommendations.

The surface shall be cleaned with water, dried and covered with oil free clean saw dust if directed by the Engineer. The final polishing shall be postponed till before handing over if so 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 sprinkled on to it and finished by buffing with felt or hessian bobs. The floor shall be cleaned with soft moist rag and dried. If desired by the Engineer, wax polish shall be applied. However, all excess wax polish to be wiped off and surface to be left glossy but not slippery.

**Acid Resistant Tile Finish**

This shall include all varieties of special tiles used for specific chemical/acid resistance function and an underbed over already laid concrete or masonry.

- **Thickness**

The total thickness of finish shall be 50 mm of which the tile shall be 25 mm, acid proof mortar 6 mm, bitumen 3 mm and cement mortar underbed 15 mm.

- **Tiles**

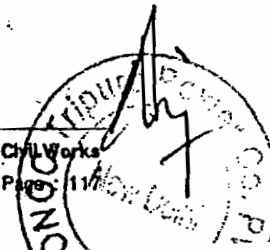
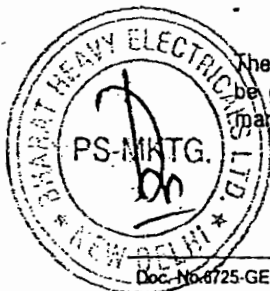
The tiles shall be of best approved manufacture, conforming to IS:4457 and resistant to the chemical likely to come in contact. The tiles shall have straight edges, uniform thickness, plain surface, uniform non-fading colour and textures. The water absorption after 24 hours of soaking shall not be more than 2% by weight. The compressive strength of tiles shall not be less than 700 kg/cm<sup>2</sup>. The surface shall be abrasion resistant and durable.

- **Under bed**

The underbed shall be laid in three layers. The first layer shall be composed for 1 part cement and 3 parts river sand with just enough water to make the mix workable. This layer shall be trowelled level and curved with water for atleast 3 days prior to application of the second layer. The second layer consist of 3 mm thick hot blown bitumen conforming to IS:702 of grade 85/25 and shall be applied in three coats with brush or spray. The third layer of acid proof mortar as specified by manufacturer shall be applied. The acid proof mortar shall have chemical resistant properties equal to that of the floor tiles.

- **Laying**

The tiles shall be embedded in the acid proof mortar and the gap between the tiles shall be grouted to the full depth of tile. The setting and fixing shall be strictly as per the manufacturer's specification and shall be approved by the Engineer.



- **Curing**

The joints in the floor shall be cured with the solution of 25% proof hydrochloric acid or as specified by the manufacturer.

**In-Situ Terrazzo Finish**

It shall consist of an underbed and a topping laid over an already laid and matured concrete base.

- **Thickness**

Unless otherwise specified the total thickness of the finish shall be minimum 40 mm for horizontal and 25 mm for vertical surface of which the topping shall be not less than 15 mm. While the topping shall be of uniform thickness the underbed may vary in thickness to provide necessary slopes. The vertical surface shall project out 6 mm from the adjacent plaster or other finish. Necessary cutting into the surface receiving the finish shall be done to accommodate the specified thickness. All junctions of vertical with horizontal shall be rounded neatly to uniform radius of 25 mm.

- **Underbed**

The underbed for floors and similar horizontal surfaces shall consist of a mix of 1 part cement, 1-1/2 parts sand and 3 parts stone chips by volume or cement sand mixture 1:3. For vertical surfaces the mix shall consist of 1 part cement to 3 parts sand by volume. The sand shall be coarse. The stone chips shall be 10 mm down well graded. Only sufficient water to be added to give a workable consistency. Stone chips are machine crushed blue granite metal.

- **Topping**

The mix of the topping shall be composed of cement, colour pigment, marble dust and marble chips. Proportions of the ingredients shall be such as to produce the terrazzo of colour, texture and pattern approved by the 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 I.S. Sieve No. 30. The size of marble chips may be between 3 mm to 10 mm.

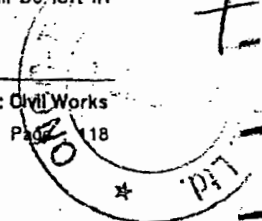
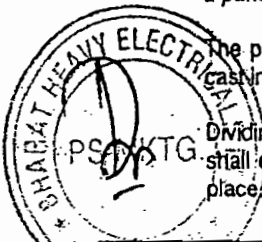
Sufficient quantity to cover all visible area shall be prepared in one lot to ensure uniform colour. Water to make it just workable shall be added to a quantity that can be used up immediately before it starts to set.

- **Laying**

The underbed shall be laid in panels. The panels shall not be more than 5 sq.m in area of which no side shall be more than 2.5 m long. For exposed locations the maximum area of a panel shall be 2.0 sq.m.

The panel shall be laid in alternate bays or chequered board pattern. No panel shall be cast in contact with another already laid until the latter has contracted to the full extent.

Dividing strips made of aluminium or glass shall be used for forming the panels. The strips shall exactly match the total depth of underbed plus topping. These strips shall be left in place.



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 troweled over, pressed and brought to a smooth dense surface showing a minimum 75% area covered by marble chips in an even pattern of distribution.

- **Curing**

The surface shall be left for curing for about 12 to 18 hours and then cured by allowing water to stand on the surface or by covering with wet sack for four days.

- **Grinding and Polishing**

When the surface has sufficiently hardened it shall be watered and ground evenly with rapid cutting coarse grade (no.60) grit blocks, till the marble chips are exposed and the surface is smooth. Then the surface shall be thoroughly washed and cleaned. A grout with already prepared mixture of cement and pigment shall be applied to fill up all pinholes. This surface shall be cured for seven (7) days by keeping it moist and then ground with the fine grit blocks (no. 120). It shall again be cleared with water, the slurry applied again to fill up any pinholes that might have appeared and allowed to be cured again for five (5) days. Finally the surface is ground again third time with very fine grit blocks (no. 320) to get smooth surface without any pin hole. The grinding shall be done by a suitable machine. Where grinding machine cannot be used hand grinding may be allowed when the first rubbing shall be with carborundum stone of coarse grade (no.60), second rubbing with medium grade (no.120).

The surface shall be cleaned with water, dried and covered with oil free clean sawdust if directed by the Engineer. The final polishing shall be postponed 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 sprinkled on to it and finished by buffing with felt or hessian bobs. The floor shall be cleaned with soft moist rag and dried. If desired by the Engineer, wax polish shall be applied. However, all excess wax polish to be wiped off and the surface to be left glossy but not slippery. The choice of grit blocks at different stages of polishing shall be as per manufacturer's recommendations.

**Carborandum Tile Finish**

It shall consist of manufactured carborandum tile and an underbed.

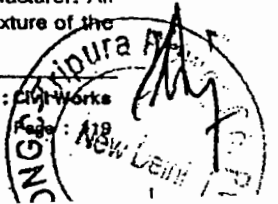
- **Thickness**

The total average thickness including underbed shall be minimum 40 mm for floors, and 30 mm for skirting unless otherwise specified.

- **Tiles**

The tiles shall be heavy duty carborandum tile 'STILAN or equivalent', machine made under quality control in a shop. The tiles shall be pressed hydraulically to a minimum of 140 kg/cm<sup>2</sup>.

Each tile shall bear on its back, permanent and legible trade mark of the manufacturer. All angles of the tiles shall be right angles, all edges sharp and true, colour and texture of the



wearing face uniform throughout. Maximum tolerance/allowance for length and breadth shall be  $\pm 1$  mm and the thickness  $+ 3$  mm along the wearing surface of the tile and the wearing surface shall be plane and free from pin-holes and other blemishes.

The tiles shall be composed of a backing and topping. The topping shall be of uniform thickness not less than 6 mm. The total thickness including the topping shall be as specified but not less than 20 mm in any case.

The backing shall be composed of 1 part ordinary grey cement, 2 parts and sand 4 parts of stone chips by volume and mixed with water.

The topping shall be carborandum grit (passing 1.18 mm mesh but retained on 0.6 mm mesh) and shall be sprinkled on the surface at the rate of 1.35 kg/m<sup>2</sup> and worked into the surface, to achieve a smooth and uniform surface.

The tile shall be cured at the shop for at least 14 days before delivery to the site. Tiles shall be packed properly to prevent damage during transit and storage. The tiles must be stored carefully to prevent staining by damp, rust, oil and grease, or other chemicals. Tiles made in each batch shall be kept and used separately so that the colour of each area of the floor may remain uniform.

The manufacturer shall supply along with the tiles the grout mix containing cement and pigment in exact proportions as used in topping of the tiles. The containers of the grout mix shall be suitably marked to relate it to the particular type and batch of tiles.

#### - Underbed

The underbed for floors and similar horizontal surfaces shall be 1 part cement, 1.5 parts coarse sand and 3 parts stone aggregate by volume mixed with sufficient water to form a stiff workable mass. For skirting and dado and all vertical surfaces it shall be about 10 mm thick and composed of 1 part cement and 3 parts coarse sand by volume.

#### - Laying

The underbed mortar shall be evenly spread and brought to proper grade and consolidated to a smooth surface. The face shall be roughened for better bond. Before the underbed has time to set and while it is still fairly moist but firm, cement shall be hand-dusted over it or a cement slurry applied and the tiles shall be immediately placed upon and firmly pressed by wooden mallet onto the underbed until it achieves the desired level. The tiles shall be kept soaked for about 10 minutes just before laying. The joints between tiles shall be as close as possible and not more than 1.5 mm wide.

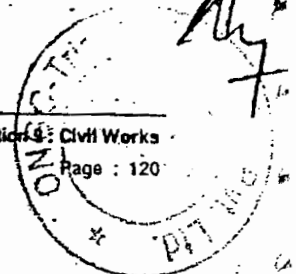
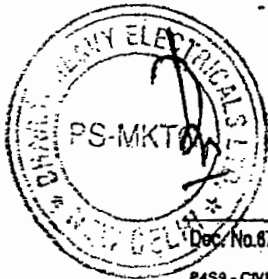
Special care shall be taken to check the level of the surface and the lines of the joints frequently so that they are perfect.

When tiles are required to be cut to match dimension. These shall be sawn and the edges rubbed smooth. The location of cut tiles shall be planned in advance and approval of the 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.

#### PVC or Vinyl Asbestos Tile/Sheet Finish

This shall include various types of tiles or sheets manufactured from PVC, set with a sticker on concrete or masonry or particle base. An underbed may be required to secure desirable surface and grade.



- **Thickness**

The thickness of the tiles/sheets shall be 2 mm for light duty and 3.02 mm for heavy-duty applications. The total average thickness including the underbed shall be 40 mm.

- **Tiles**

Unless otherwise specified, the tiles/sheets shall conform to the requirements of IS:3461 & IS:3462 and shall be of approved dimensions. The tolerance in dimensions shall be ± 1.5 mm.

The face of the tiles shall be free from porosity, blisters, cracks, embedded foreign matters or other physical defects which affect appearance or serviceability. All edges shall be cut true and square.

The colour shall be non-fading and uniform in appearance insoluble in water and resistant to alkalis, cleaning agents and usual floor polishes.

Each tile shall be marked on the back legibly and indelibly with manufacturer's trade mark, the thickness, sizes, batch number and date of manufacture.

Tiles/sheets shall be delivered securely packed and stored in a clean, dry, well ventilated place at a temperature near about to that the tiles/sheets shall be called upon to stand ultimately.

Adhesive to be used for sticking the tiles or sheets shall be neoprene based rubber adhesive of approved make and approved by the manufacturer of the tile. The adhesive shall have a short drying time and long life in addition to toughness.

- **Underbed**

The underbed where required to make-up the specified thickness or to give the required grade or to get the right type of surface shall be composed of 1 part cement : 2 parts of coarse sand : 4 parts stone aggregate 10 mm down size, mixed with just sufficient water to make it workable.

- **Laying**

The tiles or sheets shall be kept in the room to be tiled for at least 24 hours to bring them to the same temperature as the room. For air conditioned space, the air-conditioning shall be completed before tiling is taken-up.

The surface to receive this finish shall be firm, even textured, but not too smooth, without undulations and other deficiencies. If an underbed is laid, the same shall be cured for at least 7 days by keeping it moist and then fully dried.

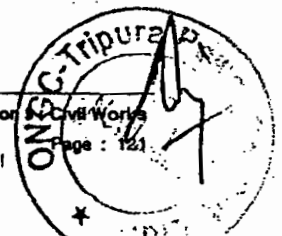
The surface shall be thoroughly cleaned. All loose dust particles shall be removed. Oil and grease, if any, shall be completely cleaned by use of detergent.

The adhesive shall be applied to fully dry surface in desired thickness uniformly. The adhesive shall also be applied to the backs and edges of the tiles or sheets and allowed to surface dry. The tiles and sheets shall be placed neatly on the surface exactly to the approved pattern and set with a suitable tool. If the edges tend to curl up, weights shall be used to keep the edges down. Special care shall be taken to avoid formation of air pockets under the tiles or sheets. The joints shall be very fine. Any adhesive squeezed out through the joints shall be removed immediately.



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- **Finishing**

If any adhesive mark is there on the surface, a soft cloth soaked in solvent shall be used to wipe it off. The surface shall be cleaned with soft water and soap, dried and polished with an approved type of polish just before handing over.

- **Epoxy Floor Coating**

Epoxy floor coating shall consist of a solvent based, two pack system with epoxy resins and amine curing agents, chosen to withstand high degrees of chemical and abrasive action.

- **Thickness**

Thickness of the epoxy coating including screeding shall be minimum 3 mm. Total thickness of finish including underbed shall be 40 mm when applied on floors of buildings. In pits and dyke areas, no underbed is required to be provided.

- **Materials**

The screed shall be solvent free combination of epoxy resin, modified amine hardeners filled with specially graded and selected chemically inert aggregates of high strength. The system shall include an epoxy resin primer and screed which are both supplied in pre-weighed units ready for on-site mixing and application.

An epoxy resin sealing coat of specified thickness shall form the topping coat.

- **Underbed**

Underbed shall be similar to that PVC floor finish.

- **Laying**

The surface shall be sound, clean and dry in order to achieve maximum adhesion with the primer coating.

The primer shall be applied by brush and shall be allowed to become tacky. The screed shall be prepared as per manufacturers specification and laid in specified thickness evenly over the base floor by trowel. The finished, cured screed shall have a slightly granular texture of uniform brown.

The epoxy resin topping shall be applied at least 24 hours after the laying of the screed. This topping shall be applied by brush or sprayed to a specified thickness in two coats with 3-5 hours interval between them. Care shall be taken to finish the topping perfectly smooth and devoid of any bubbles and unevenness. The newly laid floor shall be protected from dust or moisture and allowed to be used only after a minimum lapse of 48 hours.

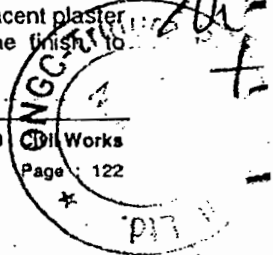
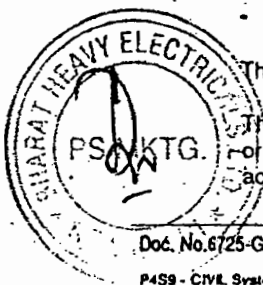
- **Ceramic Floor Tile/Glazed Wall Tile Finish**

This finish shall be composed of glazed earthen ware tiles with an underbed laid over a concrete or masonry base.

- **Thickness**

The total thickness shall be between 20 mm and 25 mm including the underbed.

The tile finish on vertical surface shall project out 6 mm uniformly from the adjacent plaster or other wall finishes. The necessary cutting into the surface receiving the finish to accommodate the specified thickness shall be done.



- Tiles

The glazed tiles shall be of earthenware, covered with glaze, white or coloured, plain or with designs, of 100 mm x 100 mm nominal sizes and 5 mm thick, unless otherwise specified. Ceramic floor tiles shall be of matt finish, white or coloured, plain or with designs of

150 mm x 150 mm nominal size and 6 mm thick, unless otherwise specified. The tolerances shall be ± 1.5 mm for length and breadth and + 0.5 mm for thickness.

Specials like internal and external angles, beads, coves, cornices, corner pieces etc. shall match. The top surface of the tiles shall be glazed with a gloss or matt unfading stable finish as desired by the Engineer. The tiles shall be flat and true to shape. The colour shall be uniform and fractured section shall be fine grained in textures, dense homogenous. The tiles shall be strong and free from flaws like cracks, chips, craze, specks, crawlings etc. and other imperfections. The edges and the underside of the tiles shall be completely free from glaze and the underside shall have ribs or indentations for better anchorage with the fixing mortar. The coloured tiles, when supplied, shall preferably come from one batch to avoid difference in colour.

- Underbed

The mix for the underbed shall consist of 1 part cement and 3 parts coarse sand by weight, mixed with sufficient water or any other mix if specified.

- Laying

Procedure for laying shall be same as that for precast terrazzo tiles.

- Finishing

The joints shall be cleaned and flush pointed with white cement and cured for seven (7) days by keeping it wet. The surface shall be cleaned with soap or suitable detergent, washed fully and wiped with soft cloth to prevent scratching before handing over.

9.5.12 Doors, Windows, Louvres, Rolling Shutters & Glazing

9.5.12.1 Scope

This specification covers the requirements in respect of materials, workmanship and quality for doors, windows louvres, Rolling Shutters and glazing work.

9.5.12.2 Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

**Metal Doors & Windows**

IS:733 Wrought aluminium and aluminium alloy bars, rods and sections (for general engineering purposes)

IS:1038 Steel doors, windows and ventilators

IS:1361 Steel windows for industrial buildings



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- IS:1948 Aluminium doors, windows and ventilators  
 IS:1949 Aluminium windows for industrial buildings.  
 IS:4351 Steel door frames

**Timber Doors**

- IS:4021 Timber door, window and ventilator frames  
 IS:1003 Timber paneled and glazed shutters.  
 IS:2191 Wooden flush door shutter (cellular and hollow core type)  
 IS:2202 Wooden flush door shutters (solid core type)

**Rolling Shutters**

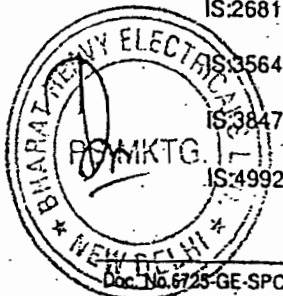
- IS:6248 Metal rolling shutters and rolling grills

**Glazing**

- IS:1081 Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators  
 IS:2553 Safety Glass - Specifications  
 IS:2835 Flat transparent sheet glass  
 IS:3548 Code of practice for glazing in buildings  
 IS:5437 Figured rolled and wired glass

**Builder's Hardware**

- IS:204 Tower bolts  
 IS:205 Non-ferrous metal butt hinges  
 IS:208 Door handles  
 IS:281 Mild steel sliding door bolts for use with padlocks  
 IS:363 Hasps and staples  
 IS:723 Steel counter sunk head wire nails  
 IS:1823 Floor door stoppers  
 IS:2209 Mortice locks (vertical type)  
 IS:2681 Non-ferrous metal sliding door bolts for use with padlocks  
 IS:3564 Door closers (hydraulically regulated)  
 IS:3847 Mortice night latches  
 IS:4992 Door handles for mortice locks (vertical types)



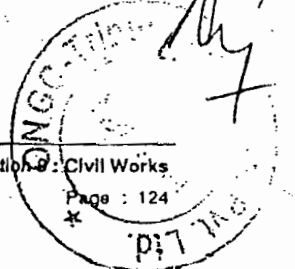
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IS:6607 Rebated mortice locks (vertical type)

## 9.5.12.3 Materials &amp; Workmanship

## Steel doors, Windows, Ventilators Etc.

## - Door Frames

Frames shall be rolled or pressed sections from 18 g sheet conforming to IS:4351. They shall be mortised, reinforced, drilled and tapped for hinges and lock and bolt strikes. Where necessary, frames shall be reinforced for door closures. Welded construction with mitred corners shall be used. Rubber door silencers shall be furnished for the striking jamb. Loose T masonry anchors shall be provided. Frames shall finish flush with floor and adjustable floor anchors shall be supplied. Frames shall be brought to site with floor ties/ weather bars installed in place.

## - Double Plate Flush Door Shutters

Door shutters shall be 45 mm thick, completely flush design and shall comprise of two outer sheets of 18 g steel sheets, rigidly connected and reinforced inside with continuous vertical 20 g stiffeners, spot welded in position at no more than 150 mm on centres. Both edges of doors shall be joined and reinforced full height by steel channels placed immediately inside and welded to the door faces. Top and bottom of doors shall be reinforced horizontally by steel channels running full width of door. Doors shall not have more than 2.5 mm clearance at jambs and head, shall have proper bevel on lock stiles and rails to operate without binding, and shall be reinforced at corners to prevent sagging or twisting. Pairs or double doors shall have meeting-stile edges beveled or rebated.

Doors shall be mortised, reinforced, drilled and tapped in shop for hinges, locks and bolts. They shall also be reinforced for closures, push-plates and other surface hardware where necessary. Any drilling and tapping required for surface hardware shall be done at site. Where necessary, provision shall be made for fixing glazing, vision panels, louvres etc. glazing mouldings shall be of 18 g steel and suitable for fixing 6 mm glass. Louvre blades shall be V or Z shaped and made out of 16 g sheets.

## - Sliding Doors

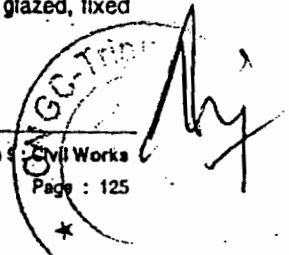
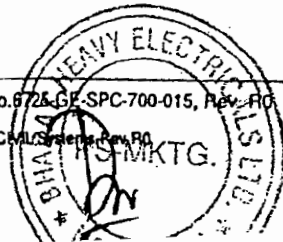
Sliding doors shall be double plate construction made out of 18 g steel sheets with adequate stiffness. The Contractor shall specify the weight of the door in his shop drawing and submit the manufacturer's catalogue of the sliding gear he proposes to use. Where shown on drawings, the Contractor shall make provisions for openings in the door for mono-rail beams. Doors shall close positively to exclude rain water from seeping in. Sliding doors shall withstand specified wind loads without buckling or jamming. The door shall slide freely under all ambient conditions.

## - Steel Windows, Sashes, Ventilators, etc.

These shall conform in all respects to IS:1038 and IS:1361. The details as called for in the above codes shall be applicable for coupling mullions, transoms, weather bars, pivot arrangements for ventilators, etc.

All welds shall be dressed flush on all exposed and contact surfaces.

Where composite unit openings are provided the individual window units shall be joined together with requisite transoms and mullions. All windows shall be outside glazed, fixed with putty or metal glazing beads.



All welds at the corner of casement shall be done by flash butt welding process and dressed flush on all exposed and contact surfaces.

#### Aluminium Doors, Windows and Frames

Aluminium sections for fabricating doors, windows, partitions etc., shall be extruded sections conforming to IS:1948 & IS:1949 or as manufactured by Indian Aluminium Company Ltd or approved equivalent. The alloy used shall conform to IS designation HE 9-WP of IS:733.

Extruded sections shall have a minimum 2.5 mm wall thickness. All sections shall be approved by the Engineer before fabrication is taken up. Doors, frames, mullions, transoms etc. shall be anodized in a bath of sulphuric acid to provide a clear coating of minimum

0.06 mm thickness. The anodised materials shall then be sealed by immersing in boiling water for 15 minutes. A protective transparent coating shall be applied to the sections before shipment from the factory.

All work shall be fitted and shop assembled to a first class job, and ready for erection. Shop joints shall be made to hair lines and then welded or braced by such method as will produce a uniform colour throughout the work. Work on the above, other than described, shall be neatly finished with concealed fasteners. Glazing beads shall be snap fit type, without visible screws and shall be of sizes to accommodate 6 mm thick glazing.

#### Timber Doors

All timber shall be best quality well seasoned specified species free from large or loose knots cracks or other defects. Where specified, timber shall be treated with approved wood preservative before starting the joinery work, the Contractor shall have the rough timber approved by the Engineer.

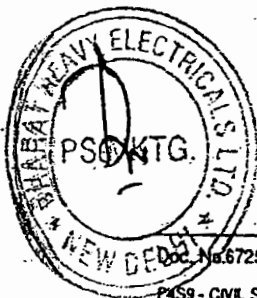
Plywood shall be of commercial quality teak veneer or with decorative surface veneer as specified.

The core for solid core doors shall be of block board or wood particle board. Manufacturer's literature and test certificates shall be submitted for the approval of the Engineer. The Contractor shall give a guarantee that the adhesive used is phenol-formaldehyde conforming to IS:848.

Fixtures for doors, windows, furniture etc. shall be as shown on drawing. These shall be of heavy type, best quality and from approved manufacturer. The Contractor shall have to mention the name of the manufacturer for different types of joinery hardware, fittings and fixtures. Samples of each type of fittings shall have to be submitted to the Engineer for obtaining approval before bulk supply.

The work shall be done by skilled carpenters as per details shown on drawing or instructed by the Engineer.

Framing timber and other work shall be close-fitting with proper wood joinery, accurately set to required lines or levels and rigidly secured in place. The surface of frames etc. which will come in contact with masonry after fixing, shall be given two coats of approved paint before fixing. Mastic caulking shall be done after fixing external door and window frames. Special care shall be taken to match the grain of timber or plywood which will be subsequently polished. Screwing or nailing will not be permitted to the edge of plywood or chip-board sheets. All exposed plywood edges shall be finished with teakwood timber lipping unless otherwise shown on drawings.



All carpentry work after finishing shall be sand papered smooth. A prime coat paint shall be given after inspection of the Engineer to all surfaces other than those which shall be subsequently polished or covered with laminated plastic sheet.

When shown on drawings decorative ply or laminated plastic sheets shall be bonded under pressure to the surface to be finished. The adhesive used shall be of approved brand and bought to site in sealed containers. The rate of application and the length of time for which the pressure is to be applied shall be as per the manufacturer's instruction. The edge of sheets shall be protected by teakwood timber lipping. However, where available factory made ready for use material of reputed manufacturer shall be used.

All frames shall be square and flat at the time of delivery and shall be checked for dimensions and corner angles. After fixing they shall be on a fine vertical plane. All external door and window frames shall be caulked with mastic.

#### PVC Doors & Windows

PVC doors and windows shall be obtained from reputed manufacturers and shall be SINTEX or approved equivalent quality. The material used shall be unplasticised PVC having superior impact resistance. Density of the material shall be 1.4 grams/cm<sup>3</sup> and tensile stress and bending stress of 480 and 770 kilopascal/cm<sup>2</sup>. The outer section wall thickness shall be min. 1.7 mm.

The section shall be reinforced with steel sections concealed inside a cavity of PVC sections. Corners shall be welded, transoms/mullions welded or mechanically joined. Weather sealing shall be by double sealing with elastomeric weather strip, the corners being glued.

Opening for PVC doors/windows shall be 10 mm more than the window/door size.

The doors shall be fixed to the wall by expandable fasteners or by brackets. Manufacturer's recommendation shall be followed for installation.

Rolling shutter (Hand operated, Mechanical gear operated and Electrically operated)

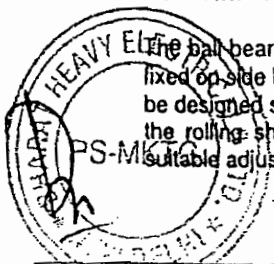
Rolling shutters shall be fabricated from 18 gauge steel and machine rolled with 75 mm rolling centres with effective bridge depth of 12 mm lath sections, interlocked with each other and ends locked with malleable cast iron clips to IS:2108 and shall be designed to withstand a wind load of 200 Kg/m<sup>2</sup> without excessive deflection.

The guides shall be either rolled or pressed deep channel sections 75 mm and 25 mm wide fitted with necessary fitting and fixtures.

The suspension shaft shall be formed from heavy duty tubes conforming to IS:1161 and of sufficient diameter so as to resist deflection due to weight of the rolling shutter. The deflection shall not exceed 5 mm/ metre width. The shaft shall be provided with C.I pulleys and helical springs for counter balancing the weight of the shutter adequately.

The springs shall be approved high tensile flat springs conforming to Grade 2 of IS:4454. These shall be fitted inside the fabricated housing of either ends which counter-balance the shutter curtain.

The ball bearings shall be double row self-aligning ball bearings fitted inside C.I. housing fixed on side brackets holding the suspension shaft at either end. The roller assembly shall be designed so as to be capable of producing sufficient torque to ensure easy operation of the rolling shutter in any position. The spring tension shall be adjustable by means of suitable adjustments holes drilled on the rims of the pulley.



The hood cover shall be made of 20 gauge galvanized sheets with necessary stiffeners and framework to prevent sag. The bottom lock plate shall be made of 5 mm thick M.S. plate and 95 mm wide reinforced with angle/T iron of suitable section with 6 mm dia M.S. rivets interlocked with last stride of curtain.

The locking arrangement shall consist of sliding bolts at both ends of the bottom plate fitted to engage with suitable receiving pockets at the bottom of guide channels.

Unless otherwise specified, for overall area of rolling, shutters up to 9 sq.m pull and push type hand-operated shutters shall be used; for area between 9 and 12 sq.m pull and push type shutters shall be provided with ball bearings; for area larger than 12 sq.m mechanical gear type or electrically operated shutters shall be supplied.

#### Glazing

Glass for glazing shall be of the following types:

- 4 mm thick transparent sheet glass conforming to IS:2835 generally used for openable shutters of windows.
- 6 mm thick wired glass conforming to IS:5437 generally used for fixed shutters of windows.
- 6.3 mm thick laminated safety glass conforming to IS:2553 generally used for fixed glazed partitions.
- 6 mm thick transparent sheet glass used for aluminium glazed doors.

All glass shall be cut according to the sizes required as per drawings. Glazing of metal doors, windows and ventilations shall conform to IS:1081 either with putty or metal clips. The Contractor shall thoroughly clean all glass and replace all putty or glass damaged during the work.

#### Double Glazing

Shall be as per approved manufacturer's specifications and relevant IS codes.

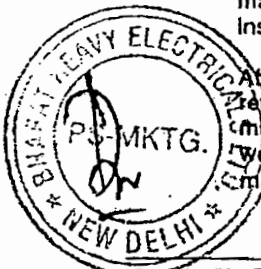
#### 9.5.12.4 Storage and Handling

All metal doors, windows etc. shall be packed and crated properly before despatch and shall be stored under cover in a way to prevent damage or distortion. Special care shall be taken to prevent staining of aluminium products by rust or mortar etc. Glass shall be brought to site in manufacturer's original packing.

#### 9.5.12.5 Assembly and Erection

The Contractor shall assemble and install all doors, windows, louvers, etc. including transoms mullions for composite units in respective places keeping proper lines and levels, and in approved workman like manner, to give trouble free and leak proof installations. The installations shall be done according to the instructions of the manufacturer and/or as approved by the Engineer. If required by the Engineer, the installation shall have to be carried out under the supervision of the manufacturer's staff.

After installation of steel doors, windows etc. all abrasions to shop-coat of paint shall be retouched and made good with the same quality of paint in shop coat. All coupling mullions, transoms, frames etc. in contact with adjacent steel and other members shall be well bedded in mastic. Door shutters, partitions, hardware fixtures shall be fixed only after major equipments have been installed in rooms.



**9.5.12.6 Hardware and Fixtures**

Hardware and fixtures shall be best quality from the approved manufacturers and shall conform to the relevant IS specification and able to withstand repeated use. The Contractor has to provide the required number / size of fixtures for trouble free operation and adequate strength. Door closers shall be suitable for shutter weight and shall be guaranteed against manufacturing defect for one year and any defect found within this period shall be rectified or the door closer replaced without extra cost to the Owner.

The Contractor shall submit samples of each type of hardware to the Engineer and the approved samples shall be retained by the Engineer for comparison with bulk supply.

**9.5.13 Painting, Colour Washing Etc.****9.5.13.1 Scope**

This specification covers the requirements in respect of materials, workmanship and quality for finishing works, such as white washing, colour washing, distemping and painting to masonry, concrete, timber and metal surfaces of doors, windows, rolling shutters etc. Separate specification shall be referred for painting of structural steel work.

**9.5.13.2 Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Indian Standards Institution and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

White washing, colour washing and distemping

- IS:427 Distemper, dry colour as required
- IS:428 Distemper, oil emulsion, colour as required
- IS:6278 Code of practice for white washing and colour washing

Painting

- IS:5 Colours for ready mixed paints and enamels
- IS:102 Ready mixed paint, brushing, red lead, non-setting, priming
- IS:123 Ready mixed paint, brushing, finishing, semigloss, for general purposes
- IS:1477 Code of practice for painting of ferrous metals in buildings
- IS:2074 Ready mixed paint, air drying, red oxide-zinc chrome, priming
- IS:2338 Code of practice for finishing of wood and wood based materials.
- IS:2339 Aluminium paint for general purposes in dual container
- IS:2395 Code of practice for painting concrete, masonry and plaster surface
- IS:2982 Enamel, synthetic, exterior, a) undercoating, b) finishing.



- IS:2933 Enamel, exterior, a) under coating, b) finishing.  
 IS:5410 Specification for cement paint, colour as required  
 IS:5411 Specification for plastic emulsion paint

**9.5.13.3 Materials****Distemper**

Dry Distemper shall be made from suitable pigments, extenders lime proof tinters, water soluble binders conforming to IS:427. Oil bound washable distemper shall be of oil emulsion type containing suitable preservatives conforming to IS:428.

**Gum and blue pigment**

Gum and blue pigment for white wash shall be of best quality and of approved make.

**Water Proof Cement Paint**

Water proof cement paint shall be made from best quality white cement and lime resistant colours with accelerators, water proofing agents and fungicides. The paint shall conform to IS:5410.

**Paint**

The painting and finishing materials for use in the work shall conform to relevant Indian Standards specifications and shall be best brands of approved make produced for each kind of work. Aluminium paint shall be in two back containers and shall resist weathering.

The acrylic emulsion paint, after it is dried, shall be able to withstand washing with mild soap and water without any deterioration in colour or without showing flaking, blistering or peeling.

**Primer coat**

Unless otherwise specified, the primer coat for concrete, steel and iron work shall be as specified by the manufacturer.

**Weather Shield coating**

Shall be as per approved manufacturer's specifications and relevant IS codes.

**Acrylic Emulsion Paint**

Shall be as per approved manufacturer's specifications and relevant IS codes.

**Textured Paint**

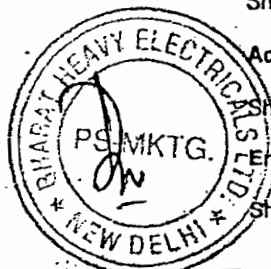
Shall be as per approved manufacturer's specifications and relevant IS codes.

**Acid Resistant Paint**

Shall be as per approved manufacturer's specifications and relevant IS codes.

**Enamel**

Shall be as per approved manufacturer's specifications and relevant IS codes.



## 9.5.13.4 White Washing, Colour Washing and Distempering

**Mixing**

The slaked lime shall be screened to pass through a sieve of 49 meshes per sq.cm. and dissolved in a tub with sufficient quantity of water and shall be well mixed to give a thin creamy consistency. It shall then be strained through a clean coarse cloth and clean gum dissolved in hot water added to it at the rate of 2 kg for each cubic meter of lime and ultramarine blue added to the mixture in small proportion just sufficient to give a very light bluish tint.

Colour wash shall be prepared in the same way as for white washing except that necessary amount of colouring matter shall be added to lime wash to obtain the colour specified. No blue shall be added in this case. The entire quantity shall be mixed strictly in accordance with the manufacturer's instructions unless these are varied by the Engineer.

Distemper shall not be mixed in a larger quantity than is actually required for a day's work and hot water shall be used in preparing the mixture.

**Preparation of Surface**

Before white wash is laid on new wall, the surface of wall shall be well cleaned and brushed and all patchings must be scraped properly. After cleaning the surface, all holes, cracks and patches shall be made good with approved materials.

Masonry cracks shall be cleaned out and patch filled with mortar similar to the original surface and finished with cement wash. For all internal painting the surface shall be made smooth by application of approved paste fillers before applying primer.

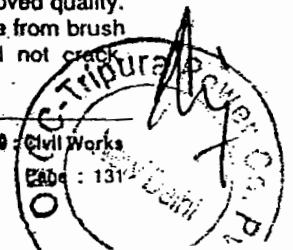
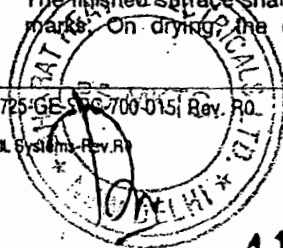
The distemper shall not be applied on damp walls and shall be applied in dry weather. The surface to be distempered shall be thoroughly cleaned of dust, dirt, grease, oil marks, cement marks, loose scales etc. and rubbed with sand paper to give a uniform smooth surface.

**Workmanship**

White wash shall be applied with brush, each coat consisting of vertical stroke from top downwards followed by opposite stroke upwards over the first stroke and horizontal stroke from left to right followed by stroke right to left. Each coat must be allowed to dry before the next coat is applied. On completion, the surface when it becomes dry, shall present a uniform white appearance. When dry, no coat of white wash shall show any patches, haircracks or streaks nor shall it come off when rubbed with hands. White washing shall be done in 3 coats unless otherwise specified. Doors, windows, floors etc. must be protected from white wash splashes. Any splashes and droppings shall be removed and cleaned.

Colour wash shall be applied in the same manner as specified for white wash. During application, the solution shall be stirred continuously and wash shall be applied with care to avoid any cut shade or brush marks on the walls when the work is complete. For all new work, the surface to be colour washed shall first be treated with a priming coat of lime wash. Unless otherwise specified, two coats of white wash shall first be applied before colour wash is applied. The colour wash, whether applied inside or outside of a building shall be of uniform tint and shade.

The workmanship for distempering shall conform to IS:427 and IS:428 unless specified otherwise. Distempering shall be done with proper distemper brushes of approved quality. The finished surface shall be of absolutely uniform shade throughout and free from brush marks. On drying, the distemper shall not come off on touch and shall not crack.



Distemper shall be applied in two coats over one coat of priming. The priming coat shall be as specified and the primer shall be in accordance with the recommendation of the manufacturer. Before applying the primer, the plastered surface shall be washed with a solution of 100 gm of zinc sulphate to one litre of water and then allowed to dry. Succeeding coats shall not be applied until the previous coat has been approved by the Engineer. The first coat shall always be of a lighter tint and shall be applied with care. In case the finish is not upto the standards, the entire surface shall be sand-papered and a fresh coat or coats of distemper shall be supplied without any extra cost.

All decorative mouldings, cornices, bands etc. shall be finished according to detailed drawings. All splashes of distemper shall be removed by the Contractor at his own cost.

The surface to be coated with water proof cement paint shall be washed and brushed down. As soon as the moisture has disappeared, the surface shall be given one coat of paint. Care shall be taken so that the paint does not dry out too rapidly. After four to six hours, water shall be sprinkled over the surface to assist curing and prevent cracking. After the first coat has dried (24 to 48 hours), the second coat shall be applied in a similar manner. The finished surface shall be kept moist by occasional sprinkling with water for seven days after painting.

#### 9.5.13.5 Painting

##### Preparation of surface

The surfaces of iron and steel work to be painted shall be cleaned free of dirt, oil, rust, millscale and be thoroughly dry before painting. Cleaning, degreasing, derusting and descaling wherever necessary shall be carried out as specified in IS:1477 (Part I). All galvanised iron surfaces shall be pre-treated with a compatible primer according to the manufacturer's direction.

The surfaces of wood shall be rubbed down smooth. All nails and screws shall be sunk below the surface and filled with mastic after applying an under coat. Small knots that do not justify cutting and sap streaks shall be covered with minimum two coats of pure shellac coating applied thinly and extended 25 mm beyond the area. All large, loose or resinous knots shall be removed and filled with sound wood. All work shall be done as per IS:2338.

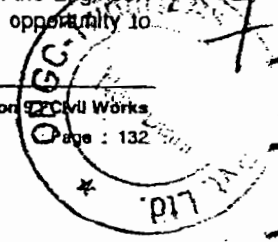
##### Application

Painting of iron and steel work shall generally be carried out as per IS:1477.

The paint manufacturer's specification/instructions shall be followed as far as possible at all times. Particular attention shall be paid to the following:

- Proper storage to avoid exposure, as well as extremes of temperature.
- Surface preparation prior to painting
- Mixing and thinning
- Application of paints and the recommended time limit on time intervals between coats.

Painting operations shall not proceed until the Engineer has the opportunity to inspect the condition of prepared surface to be painted. Paint shall be thoroughly mixed and not more than 1/2 kg of recommended thinner per 4.5 kg litres of paint shall be added if thinning is necessary. Exterior paint shall not be performed during the period of inclement weather. Interior painting may proceed during such periods only with the approval of the Engineer. Prior to application of subsequent coat, the Engineer shall be given the opportunity to



inspect the prior coat. Should the work be judged by the Engineer to be inferior, a supplementary coat shall be applied at no additional cost.

The number of coats including the primer coat shall be applied as specified. Each coat shall be allowed to dry sufficiently before the succeeding coat is applied.

The type of intermediate and finish coat and the number of coats to be applied shall be as specified. Intermediate and finish coats may be oil bound, bituminous, aluminium or other types of paints. The intermediate and finish coats for structural steel work, sheet metal work and cast iron work shall be applied as specified in IS:1477 (Part II).

#### 9.5.13.6 Acceptance Criteria

- a) All the painted surface shall be uniform and pleasing in appearance.
- b) The colour, texture etc. shall match exactly with those of approved samples.
- c) All stains, splashes and splatters of paints shall be removed from surrounding surface.

#### 9.5.14 Water Proofing

##### 9.5.14.1 Scope

This specification covers the requirements in respect of materials, workmanship and quality for water proofing of roofs and underground structures.

##### 9.5.14.2 Codes and Standards

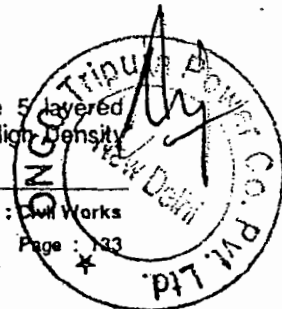
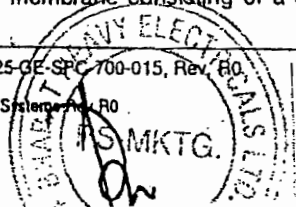
Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

IS:1322	Bitumen felts for water proofing and damp proofing
IS:1346	Code of practice for waterproofing of roofs with bitumen felts
IS:1580	Bituminous compound for water proofing and caulking purposes.
IS:1609	Code of practice for laying damp-proof course using bitumen felts
IS:2645	Integrated cement water proofing compounds (1987)
IS:3067	Code of practice for general design details and preparatory work for damp-proofing and water-proofing of building.
IS:7193	Specification for glass fibre base coal tar pitch and bitumen felts.

##### 9.5.14.3 Materials

#### Bituminous Polymeric membrane for roof water proofing.

Bituminous Polymeric membrane used for waterproofing of roofs shall be 5 layered membrane consisting of a central core of 90 microns thick High Molecular High Density



Polyethylene (HMHDPE) film protected on both sides with polymeric asphaltic mix and further covered on both sides with protective thermofusible HMHDPE film. For precast roofs, the top HMHDPE layer shall be substituted with embossed aluminium foil 75 microns thick. Product to be used for cast-in-situ roof slab shall be MULTIPLAS STANDARD and that for roof with precast slab panels shall be MULTIPLAS ALUMINIUM or approved equivalent.

#### Bituminous polymeric membrane for underground damp proofing.

The membrane used for waterproofing underground structures shall be 7 layered membrane similar to 5 layered roofing membrane, but reinforced with a non woven polyester mat of minimum 140 g/m<sup>2</sup> for additional mechanical strength and covered with additional layer of polymeric asphalt. Product to be used shall be MULTIPLAS HYPER or approved equivalent.

#### Bitumen Felt

It shall conform to IS:1322.

#### Fibre Glass Tissue Reinforced Bitumen Felt

It shall conform to IS:7193, consisting of reinforced glass fibre base coated on both sides with bitumen modified with thermo plastic polymers.

#### Bonding Materials

Bonding materials used for applying the polymeric bituminous membrane on surfaces shall be fibre and solvent based, rubber modified bituminous primer of density 0.92 g/cm<sup>3</sup> with viscosity 500 to 10,000 cps. Ordinary bitumen wherever used shall be of blown type conforming to IS:702 or residual bitumen conforming to IS:73 or a mixture thereof.

#### Water proofing admixture

The water proofing admixture shall conform to IS: 2645 and shall be approved by the Engineer.

#### Cement

Cement shall conform to IS:269.

#### Aggregates

The aggregates shall conform to IS:383. Fine aggregate shall be river sand or pit sand from approved pits. Coarse aggregate shall be stone chips of size not exceeding 6 mm.

#### Metal Flashings

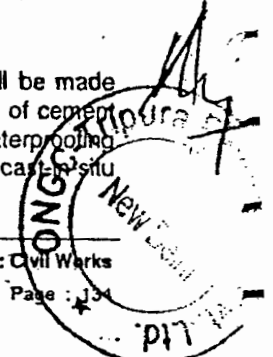
Metal flashings shall be of 18 g or 20 G galvanised iron.

#### 9.5.14.4 Workmanship

##### Waterproofing of roof

With polymeric bituminous membrane

The roof slabs shall be cleaned of all dust, dirt, grit etc. and if rough it shall be made reasonably smooth either by clipping of projections or by applying a thin coat of cement slurry of cement sand and water. The roof surface shall be regraded prior to waterproofing with cement mortar or concrete screed to provide a minimum slope of 1:75 for cast-in-situ



roofs and 1:50 for precast roofs. At the places of drain outlets, projecting pipes, parapet walls and expansion joints etc. the surface shall be prepared as indicated in IS : 1346.

Over the hardened and finished surface of roof slab, suitable approved primer such as MULTIPLAS PRIMER or approved equivalent is coated at the rate of 250 g/cm<sup>2</sup>. The waterproofing membrane is unrolled over the coated surface with overlaps of 100 mm and bonded completely to the substrate. The overlaps are then sealed by flame. Installation of the waterproofing membrane shall be strictly as per the manufacturer's instructions and supervision.

In case of roofs with parapets, a chase 75 mm deep shall be cut in the parapet masonry at about 150 mm above the roof level and the membrane shall be laid as flashings in widths with a minimum overlap of 100 mm. The lower edge of the flashing shall overlap the membrane laid on the flat portion, and the upper edge of the flashing shall be tucked into the groove made in the parapet. After the flashing has been properly bonded, the chase shall be cleaned and shall be filled up with cement mortar 1 : 4 flush with the face of the wall, and allowed to set by adequate curing.

For gutters, the membrane shall be laid over a primer coat, and finally painted with a coat of hot bitumen at not less than 1.5 Kg/sq.m. The membrane treatment shall be carried down into the outlet pipes to a minimum depth of 100 mm.

After the treatment is over, the surface shall be covered with 20 mm plaster of cement mortar 1:4 reinforced with chicken wire mesh marked off into squares 600 mm wide with expansion joints provided at a distance of 3 metres for cast-in-situ accessible roofs.

**- With hessian based bitumen felts**

The roof slab shall be cleaned of all dust, dirt, grit etc. and if rough it shall be made reasonably smooth either by chipping of projections or by applying a thin coat of cement slurry of cement, sand and water.

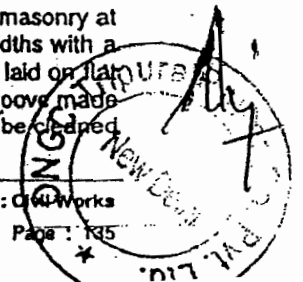
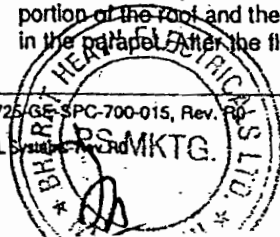
The roof surface shall be regraded prior to waterproofing either with cement mortar or lime-surkhi mortar. At the places of drain outlets, projecting pipes, parapet walls and expansion joints etc. the surface shall be prepared as indicated in IS:1346.

The workmanship in general shall conform to IS:1346 unless otherwise specified. Over the hardened and finished surface of the roof slab, a thin layer of approved bitumen primer shall be first brushed over the roof surface and allowed to dry.

The felt shall be first cut to the required lengths and laid out flat on the roof in position at right angles to the direction of run-off gradient and shall be brushed clean of dusting materials. Each length of felt thus laid in position shall be rolled up for a distance of half of its length. Then the bonding material heated to correct temperature shall be poured on to the roof across the full width of the rolled felt as the latter is steadily rolled out and pressed down. Excess bonding material shall be squeezed out at the ends and removed as the laying proceeds: When the first half of the strip of felt has been bonded to the roof, the other half shall be rolled up and then unrolled on to the hot bonding material in the same way.

Minimum overlaps of 100 mm shall be allowed at the end and the sides of strips of felt. All overlaps shall be firmly bonded with hot bitumen. The laying of the second layer of felt shall be so arranged that the joints are staggered with those of the layer beneath it.

In case of roofs with parapets, a chase 75 mm deep shall be cut in the parapet masonry at about 150 mm above the roof level and the felt shall be laid as flashings in widths with a minimum overlap of 100 mm. The lower edge of flashing shall overlap the felt laid on flat portion of the roof and the upper edge of the flashing shall be tucked into the groove made in the parapet. After the flashings have been properly bonded, the chase shall be cleaned



and shall be filled up with cement mortar (1:4) flush with the face of the wall and allowed to set by adequate curing.

In case of drain mouths, waterproofing shall be done as specified for the roof excepting that the treatment shall be carried inside the drain pipes overlapping at least 100 mm.

For gutters, a priming coat shall first be applied. Over this, a specified number of layers of felt shall be laid and bonded together with hot bitumen and finally painted with a coat of hot bitumen at not less than 1.5 kg per sq. metr. The felt layers laid separately in the gutters shall be overlapped with the corresponding layers on the roof proper. The felt treatment shall be carried down into the outlet pipes to a minimum depth of 100 mm.

After the treatment is over, the surface shall be covered by pea-sized gravel or grit at the rate of 0.6 cu.m per 100 sq.m. On flashings and at drain mouths a finish of two coats of approved bituminous primer shall be provided.

- With fibre glass tissue reinforced bitumen felt

Water proofing for roofs shall be according to the guide lines in IS:1346. Other requirements shall be the same as those for hessian based bitumen felt.

- With brick lime concrete and pressed flat tiles

The exposed surfaces of the roof slab shall be thoroughly cleaned. A layer of brick lime concrete shall be laid over the cleaned surface. Brick lime concrete shall be 1:2:4 by volume using 20 mm down graded brick bats. The slope of the lime concrete layer shall be 1:100 and the minimum thickness shall be 80 mm. The slope of the draining surfaces shall be formed on all the sides as necessary.

Care shall be taken to check the quantity of water. The quantity of water shall be so as to make the concrete just workable. Cement sand mortar 1:3 with 2% mixture of "Accoproof" (or approved equivalent water proofing agent) shall be laid over the underbed to a thickness of 20 mm. Pressed flat tiles are set over the mortar and pointed with cement mortar 1:3 with 2% "Accoproof" (or approved equivalent water proofing agent).

Damp proofing of underground structures

- With polymeric bituminous membrane

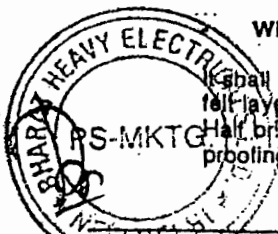
Prior to application of the membrane, the surface shall be coated with MULTIPLAS PRIMER or equivalent applied at the rate of 250 g/m<sup>2</sup>. Application procedure will be similar to roof water proofing, strictly as per manufacturer's instructions and supervision. Membranes shall be fastened with the vertical surfaces for height exceeding 4.5 mtrs. Half brick thick brick work in cm 1 : 4 shall be provided as protection to waterproofing on external side faces.

- With hessian based bitumen felts

Damp proofing for under ground structures wherever indicated shall be done as per recommendations of IS:1609, for heavy treatment with three layers of felt. The method of laying damp proofing treatment shall be as per IS:1609.

With fibre glass tissue reinforced bitumen felt

It shall be done as per guidelines laid in IS:1609 and those specified for hessian felts. The felt layers shall be fastened to the wall surface wherever the height exceeds 4.5 metres. Half brick wall in C M 1:4 shall be erected as protection to the external face of the water proofing.



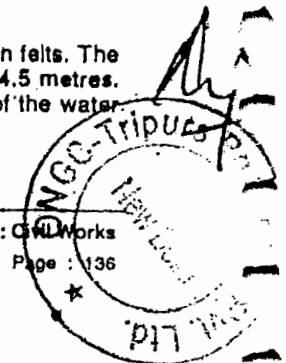
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**9.5.14.5 Acceptance Criteria**

The slopes and surface level shall be such as to allow quick draining of water without leaving any pool anywhere. The finishing course shall be fully secured and shall have an even density. There shall not be any bubble formation or crushed or squeezed insulation or underbed.

The Contractor shall give a guarantee in writing for all works executed under this specification supplemented by a separate and unilateral guarantee from the specialised agency for the waterproofing treatment work. The guarantee shall be for materials and workmanship for five (5) years.

**9.5.15 False Ceiling and False Flooring****9.5.15.1 Scope**

This specification covers the requirements in respect of materials, workmanship and quality for suspension system and ceiling panels required for false ceiling work and false flooring work.

**9.5.15.2 Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed here under :

IS:848	Synthetic resin adhesives for plywood
IS:1642	Code of practice for fire safety of buildings.
IS:2095	Gypsum plaster boards
IS:2441	Code of practice for fixing ceiling coverings.
IS:3087	Wood particle boards for general purposes.
IS:3129	Low density particle board.
IS:4671	Expanded polystyrene for thermal insulation purposes

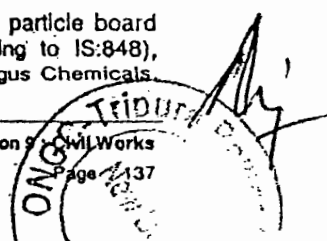
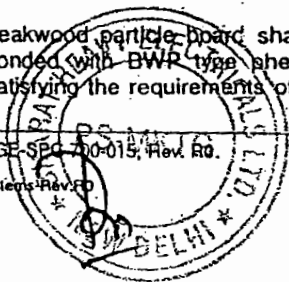
**9.5.15.3 Materials****Ceiling Panels for False Ceiling**

Ceiling panels shall be of best quality material in thickness and properties specified. The Contractor shall submit test certificate to the Engineer for approval before bulk supply.

The ceiling panels may be of the following types manufactured by reputed manufacturers

- Teakwood particle board

Teakwood particle board shall conform to IS:3087 (3 layer flat pressed particle board bonded with BWP type phenol Formaldehyde Synthetic resin conforming to IS:848), satisfying the requirements of Class I of IS:1642 and treated with antifungus Chemicals.



The bottom (facing the floor) of tiles shall be painted with two coats of acrylic emulsion paint over a coat of primer.

- **Gypsum board**

Gypsum board shall conform to IS:2095 and shall have the following properties

Thermal conductivity	:	0.16 W/mK
Thermal resistant	:	0.06 to 0.09 m <sup>2</sup> K/W
Fire propagation	:	Class-1

- **Aluminium panels**

Aluminium panels shall be square edged plain panels, 84 mm wide x 15 mm deep with 25 mm recessed flanges, formed out of 0.5 mm thick aluminium alloy electrically powder coated in standard colours. LUXALON 84C or approved equivalent shall be used.

**Floor Panels for False Flooring**

Floor panels for false flooring shall be of 35 mm thick particle board fire retardant type (Novateak or approved equivalent) faced on top with 2 mm thick vinyl P.V.C. tiles having antistatic and antiskid quality unless otherwise specified. The underside of the floor panels shall be provided with two coats of fire resistant paint over a coat of approved primer. The floor panels shall be made of particle board bonded with phenol formaldehyde and it shall be of fire/termite resistant, moisture proof quality. Each panel shall have PVC clippings on all edges. The floor panels shall be of completely removable type. The false floor should be suitable to take a point load of 450 kg. The clearance under the floor shall be as per drawing, the floor panels shall be cut wherever required for providing suitable outlets for cables etc.

**9.5.15.4 Installation**

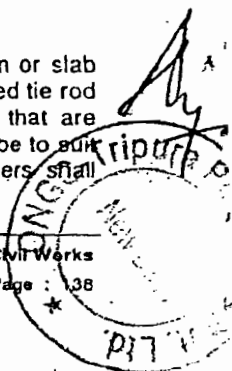
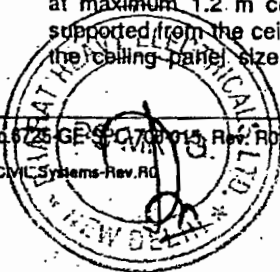
The contractor shall prepare a layout for false ceiling showing the framing and the cut outs for AC/Electrical fixtures and other services and get the same approved before commencement of work.

**Suspension system for false ceiling boards**

Suspension system shall consist of the grid supporting the ceiling panels, intermediate runner supports for the grid if any and hangers, wall angles etc. required to suspend the grid or the runners from structural walls, slabs and beams or trusses. Anodized aluminium grid ceiling system from the approved supplier shall be used. All members of the suspension system shall be of sufficient strength and rigidify to carry the ceiling boards or sheets in a true and level plane without exceeding a deflection of 1/360th of their span. Samples of suspension system shall be submitted to the Engineer and approval obtained.

Main runners shall be extruded anodized (25 microns) aluminium Tee section of minimum 25 mm x 35 mm size. Secondary runners shall be aluminium Tee section of minimum size 25 mm x 25 mm. Wall angles shall be of minimum size 38 mm x 38 mm. Generally the grid dimensions of 610 mm x 610 mm shall be adopted.

Angle cleats or other suitable fixing device shall be fixed to the structural beam or slab above for fixing of hangers. Main runners shall be hung by M.S. flats or galvanised tie rod at maximum 1.2 m centres. Extra hangers shall be provided at light fixtures that are supported from the ceiling system. The spacing of main and cross runners shall be to suit the ceiling panel size and as recommended by the supplier. The cross runners shall



intersect the main runners at perfect right angles and positively locked together with intersection clips. Cutouts for light fixtures, diffusers etc. shall be the exact dimensions and in exact locations.

#### Suspension system for aluminium panels

The panels shall be supported on formed carriers, 15 mm wide at top and 43 mm deep, made out of 0.91 min. thick aluminium alloy electrically powder coated in stain black with protruding ears to hold panels in a module of 100 mm (16 mm gap between the panels) at a maximum spacing of 1.3 metres. Carriers shall be suspended from the slab/roof by 4 mm dia galvanised steelwire/rod hangers with height adjustment suspension springs made out of galvanised spring steel hangers, fixed to slab by J hooks and nylon inserts. Edges of the ceiling shall be trimmed with suitable matching edge profiles to cover the gap between the false ceiling and the walls.

#### Supporting arrangement for false flooring

The supporting arrangement for false flooring shall consist of pedestal made out of aluminium zinc alloy rod with check nut into 20 mm dia and 10 mm thick base plates. The pedestal shall be fixed on the floor @ 600 mm c/c with araldite (or other approved method) including surface preparation. The pedestal heads will receive main end cross M.S. cold roll formed 40 mm x 40 mm x 2.5 mm thick channels including provision of additional angles 50 x 50 x 6 mm and ISMC 100 at cable entries and sides of well as required. The pedestals will have level adjustments to ± 25 mm for levelling. Each pedestal shall be able to support a load of 2500 kg without deformation. All steel framework shall be hot dip galvanised.

#### Fixing of Ceiling and Floor Panels

The Contractor shall submit sample panels and get the approval of the Engineer. Installation of ceiling and floor panels shall be strictly as per manufacturer's instruction. The hold down clips for ceiling panels shall be used at the rate of minimum one per 1.2 metre length of perimeter or as per manufacturer's specification. These shall however be omitted in access panels which shall be located as per the instruction of the Engineer.

Finished ceiling and floor shall be at the correct plane and present a pleasing and uniform appearance, free from sags, warps, disfigured or damaged boards. Joints, exposed grids etc. shall be in true lines and symmetrically placed.

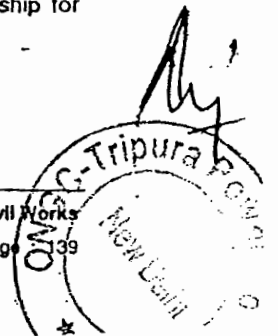
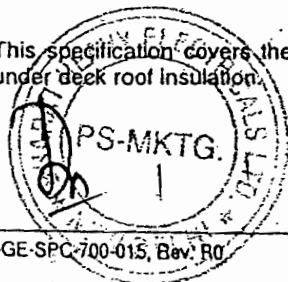
#### 9.5.15.5 Acceptance Criteria

Finished ceiling and floor shall be at the correct plane and present a pleasing and uniform appearance, free from sags, warps, disfigured or damaged boards. Joints, exposed grids etc. shall be in true lines and symmetrically placed in manner shown on drawings. Cutouts for light fixtures, diffusers, cable ducts etc. shall be to the exact dimensions and in exact locations.

#### 9.5.16 Roof Insulation

##### 9.5.16.1 Scope

This specification covers the requirements in respect of materials and workmanship for under deck roof insulation.



**9.5.16.2 Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Indian Standards Institution and all other such as may be published by them during the currency of the contract shall govern in respect of design, workmanship, quality and properties of materials and method of testing. The relevant available code is listed hereunder :

IS:8183 - Bonded mineral wool.

**9.5.16.3 Materials**

The materials for insulation shall be resin bonded mineral wool insulation of Group I as per IS:8183 with aluminium facing.

**9.5.16.4 Workmanship**

Slotted angle 50 x 50 x 6, 50 mm long shall be fixed to the underside of the slab at 600 mm centres in both direction. The insulation board or rolls shall be fixed to the underside of the slabs at 600 mm centres in both directions with the aluminium foil face at the bottom with a suitable adhesive. The insulation material shall be held in position by means of the 25 mm x 24 SWG net tied to the slotted angles. The joints if any of the wire netting shall be butted and lightly laid down with GI wire.

**9.5.17 Water Supply, Drainage and Sanitary Works****9.5.17.1 Scope**

This specification covers the requirements in respect of materials, installation and quality for water supply, drainage and sanitary works.

**9.5.17.2 Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

**Roof Drainage System**

IS:1230 Cast Iron rain water pipes and fittings

IS:1626 Asbestos cement building pipes, gutters and fittings (spigot and socket type)

IS:1729 Specification for sand cast iron spigot and socket soil, waste and ventilating pipes, fittings and accessories.

IS:1742 Code of practice for building drainage.

IS:2527 Code of practice for fixing rainwater gutters and down pipes for roof drainage

Pipes and fittings for sanitary plumbing and drainage

IS:404 Lead pipes

IS:405	Lead sheet and strip
IS:458	Concrete pipes (with and without reinforcements)
IS:651	Salt glazed stoneware pipes and fittings
IS:77	Glazed fire clay sanitary appliances
IS:774	Flushing cistern for water-closets and urinals (other than plastic cisterns)
IS:775	Cast iron brackets and supports for wash basins and sinks
IS:778	Copper alloy gate, globe and check valves for water works purposes.
IS:781	Cast copper alloy screw down bib taps and stop valves for water services
IS:782	Caulking lead
IS:783	Code of practice for laying of concrete pipes
IS:804	Rectangular pressed steel tanks
IS:1172	Code of basic requirement for water supply drainage and sanitation
IS:1239	Mild steel tubes and tubulars and other wrought steel fittings
IS:1536	Centrifugally cast(spun) iron pressure pipes for water, gas and sewage
IS:1537	Vertically cast iron pressure pipes for water, gas and sewage.
IS:1703	Ball valves (horizontal plunger type) including floats for water supply purposes
IS:1711	Self closing taps for water supply purposes
IS:1726	Cast iron manhole covers and frames
IS:1742	Code of practice for building drainage
IS:1795	Pillar taps for water supply purposes
IS:2065	Code of practice for water supply in buildings
IS:2104	Water meter boxes (domestic type)
IS:2326	Automatic flushing cisterns for urinals (other than plastic cisterns)
IS:2470	Code of practice for installation of septic tanks
IS:2548	Plastic seats and covers for water-closet
IS:2556	Vitreous sanitary appliance (vitreous china)
IS:2963	Copper alloy waste-fittings for wash basins and sinks
IS:3004	Plug cocks for water supply purposes
IS:3005	Chemically resistant glazed stoneware pipes and fittings

IS:3076	Low density polyethylene pipes for potable water supplies
IS:3114	Codes and practice for laying of cast iron pipes
IS:3311	Waste plug and its accessories for sinks and wash basins
IS:3486	Cast iron spigot and socket drain pipes
IS:3597	Methods of test for concrete pipes
IS:4127	Code of practice for laying of glazed stoneware pipes
IS:4346	Washers for use with fittings for water services
IS:4984	Specification for high density polyethylene (HDPE) pipes for potable water supplies, sewage and industrial effluents
IS:4985	Unplasticized PVC pipes for potable water supplies
IS:5219	Cast copper alloy traps ('P' & 'S' (Part-I) traps)
IS:5329	Code of practice for sanitary pipe work above ground for buildings
IS:5961	Cast iron gratings for drainage purposes
IS:7634	Code of practice for plastic pipe work for potable water supplies
IS:8008	Injection moulded high density polyethylene (HDPE) fittings for potable water supplies
IS:10124	Fabricated PVC fittings for potable water supplies

### 9.5.17.3 Materials

#### Sanitary Fittings

All sanitary fittings shall be procured from approved vendors and shall conform to the requirements of the relevant IS Codes listed above. The sizes shall be as specified in the General Technical Specification, where not specified, the same shall be as per Engineer's approval.

Glazed earthenware fittings shall be of Hindustan Sanitaryware, Parryware or approved equivalent make, white colour and one piece construction. All metallic fixtures like taps, stop cocks, soap holders etc. shall be of Chromium Plated (CP) brass, Jaguar, GEM or approved equivalent make. PVC fixtures shall be of CALIPLAST or approved equivalent make. All wall fittings shall be fixed with wooden cleats and CP brass screws and washers.

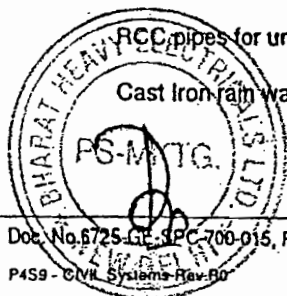
#### Pipes and Fittings

Pipes and specials shall be of standard quality conforming to IS:3486.

Stoneware pipes shall conform to IS:651.

RCC pipes for underground sewer shall be P1 class conforming to IS:450.

Cast Iron rain water pipes shall conform to IS:1230.



Water supply lines of GI, PVC, HDPE shall conform to IS:239, IS:4985 and IS:4984 respectively. PVC fittings for water supply lines shall conform to IS:10124.

The Contractor shall submit to the Engineer samples of all materials, fittings and appliances for approval well in advance of starting the work. All materials, fittings and appliances used in the work shall conform to the approved samples.

#### 9.5.17.4 General

All water supply, drainage and sanitary works shall be executed by a licensed or authorised plumbing supervisor or a license or authorised plumber and shall be in accordance with the requirements of IS:1742 and other relevant codes.

For items such as earthworks, excavation, concrete, brick work, stonework, painting etc. relevant specifications for these shall apply, unless otherwise specified.

Unless otherwise specified, all exposed work such as cisterns, brackets etc. shall be painted with one coat of red oxide paint and two coats of oil paint of approved colour.

The diameter of pipes and fittings wherever mentioned shall mean the internal diameter or nominal bore, unless otherwise specified.

The job shall include the cost of making necessary chases, holes etc. in walls, floors and in other places and also making good on completion of the works. Any damage caused to floors, walls etc. during execution of the sanitary and plumbing works shall be made good by the contractor at his own cost to the satisfaction of the Engineer.

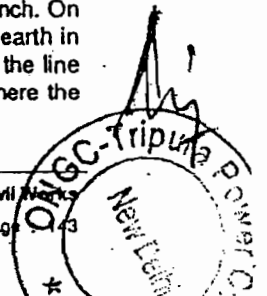
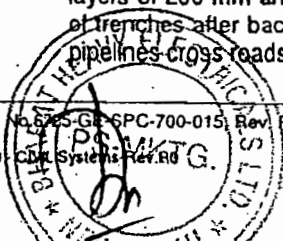
#### 9.5.17.5 Installation

All execution will be done on the basis of drawings /instruction given by the Engineer. Fittings meant for operation shall be located and oriented to allow easy reach and operation, maintenance, repairs and replacements of pipes, fittings and fixtures must be conveniently possible.

Cast iron soil and waste pipe line

##### Laying

The laying of cast Iron pipelines shall commence only after the bottom of the trench at various points have been levelled and aligned in accordance with the drawings. The sides of the trenches shall be as vertical as possible, and the width at the bottom shall be 400 mm wider than the diameter of the pipe. Where joints are made, the trench shall be widened suitably to provide room for caulking joints. Shoring and timbering shall be used where required. For pipes buried in the ground, the Contractor shall take care to maintain always a minimum cushion of earth over the pipes as indicated in the drawings. All pipes, water mains, cables etc. met within the course of excavation shall be carefully protected and supported. All pipes and fittings shall be sounded with a light hammer and check properly to detect any crack or blow holes before laying. The excavated material shall be thrown on one side of trench and the pipes stacked on the other side. The inside of socket and the outside of spigot shall be thoroughly cleaned of all foreign matter before laying. The pipes shall be laid with their socket ends facing the direction of the flow. The pipes shall be lowered in the trenches by a method as approved by the Engineer. The pipes shall then be jointed by caulking as specified under jointing. After each section of the pipeline has been laid it shall be tested for water tightness before backfilling the trench. On successful completion of testing, the trench shall be backfilled with the excavated earth in layers of 200 mm and shall be watered and rammed. Any subsidence occurring in the line of trenches after backfilling shall be repaired by the contractor at his own cost. Where the pipelines cross roads, the sides of the trenches shall be suitably shored.



When the pipe line has to be laid above ground vertically by the side of wall, it shall be securely fixed to the wall with wooden plugs and nails.

#### Jointing

The type of jointing for C.I. pipes conforming to IS: 3486 shall be socket and spigot either with molten lead or lead wool and gasket conforming to IS:782.

If the joints used are spigot and socket type, the spigot shall be carefully centred in the socket by one or more laps of clean white hemp spun yarn with about 25 mm overlap. Sufficient yarn only shall be forced into the socket to leave a correct depth of lead for caulking. The pipe shall then be examined again for line and level and the proper depth of each joint shall be tested before running the molten lead. For pouring of molten lead a ring of hemp rope shall be wrapped round the pipe at the end of the socket and the joint shall be covered with stiff damp clay. The rope shall then be removed carefully leaving a V-shaped large hole at the top of the joint to pour the molten lead. Lead shall be poured in one operation only. After a section of convenient length of pipe has been laid, lead shall be caulked sufficiently with caulking tools and hand hammered till the excess lead removed and the joint shall be made neat and clean. Depth of lead in joints from the top of socket shall be 37 mm for 150 mm dia pipes and 25 mm for 100 mm dia pipes.

The type of joint CI pipes conforming to IS:1729 shall be socket and spigot with cement and sand mortar (1:1) and gasket yarn.

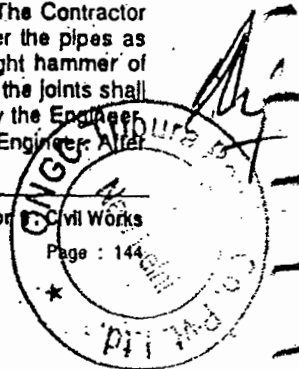
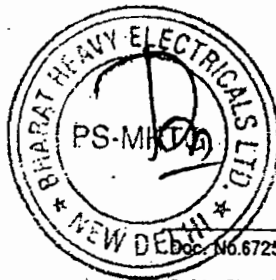
The spigot shall be carefully inserted and centered in the socket by one or more laps of thin clean hemp spun yarn and shall be forced into the socket to leave a correct depth of 30 mm all-round and level and the proper depth of each joint shall be tested before inserting the cement mortar. The joints shall then be carefully be levelled to the edge of the socket. Each joint shall be adequately cured by covering with wet clothes and pouring water at frequent intervals.

The packing ring or washer for the flanged joints shall be rubber for the full diameter of the flange with proper pipe hole and bolt holes cut out suitably. The packing shall be smeared with graphite paste or a mixture of red lead and white lead and shall be introduced between the flanges of both the pipes and nuts tightened in opposite pairs keeping the longitudinal axes of adjoining pipe lines in exactly the same straight line. Lead washers shall be provided along with bolts to prevent any leakage through bolt holes.

#### Stoneware pipes

##### Laying

The laying of stoneware pipelines shall commence only after the bottom of the trench at various points have been levelled as shown in the drawings. The centre line excavated to correct depth, slope and width at all points. The pipes shall be carefully laid to the alignment, levels and gradients as shown on the drawings. The trench shall be excavated wide enough under the sockets to allow hands to pass for making joints. The pipes between manholes shall be laid truly in straight lines and without any vertical or horizontal deviations on a bed of concrete as shown on the drawings. While laying pipes, portion of concrete under each socket shall be dug and taken off so that the barrel of the pipe gets full support on the concrete bed. Pipes shall be haunched with concrete tangentially upto the crown of the diameter of the pipe as shown on the drawings. When it crosses under a road, the pipe shall be fully encased in concrete as shown on drawings. The Contractor shall take precautions to maintain always a minimum cushion of earth over the pipes as indicated in the drawings. All pipes shall be carefully examined with a light hammer of soundness before laying. After each section of the pipelines has been laid, the joints shall be allowed to set properly and shall be inspected and tested as directed by the Engineer. Backfilling of the trench shall be carried out only after the approval of the Engineer.



testing, the trench shall be backfilled with selected earth in layers of 200 mm and shall be watered and thoroughly rammed. All pipes, water mains, cables etc. met within the course of excavation shall be carefully protected and supported.

When the pipelines cross roads, the trenches shall have vertical sides with suitable shoring. Any subsidence in the line of trench after backfilling shall be repaired by the contractor at his own cost.

#### - Jointing

The type of jointing for stoneware pipes shall be socket and spigot type. The inside of the socket shall be first painted with a thin layer of cement mortar (1:2) and a gasket of yarn dipped in cement slurry shall be inserted in the socket of the pipe with the wooden caulking tool and wooden mallet in such a way that the gasket shall fully encircle the spigot with a slight overlap. When the spigot end received the gasket, it shall be wrapped round with two or three turns of treated spun yarn at its ends before being inserted into the socket. The rest of the joint shall then be completely filled with cement sand mortar (1:1) having very little water and the joint shall be levelled to form a smooth splayed fillet at an angle of 45°. All excess of cement mortar left inside the pipe joint shall be neatly cleaned off and the joint shall be adequately cured by covering with wet gunny bags and pouring water at frequent intervals. In jointing stoneware pipes, care shall be taken that the pipes are kept concentric and the socket, specially on the underside shall be completely filled with cement mortar. Where settlement of earth is envisaged, the joint shall be made with bitumastic filler or any other materials as approved by the Engineer.

#### Concrete pipes

##### - Laying

The laying and jointing of pipes shall conform to IS:783. The trench shall be checked for proper level, gradient and alignment before lowering the pipes.

The pipes shall be lowered cautiously to prevent disturbance of the bed and sides of the trench. The heavy pipes shall be lowered by means of proper shear legs, chain pulley blocks or as directed by Engineer. Great care should be taken to prevent sand etc. from entering the pipes.

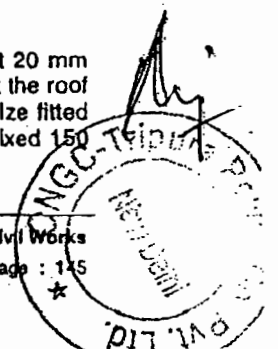
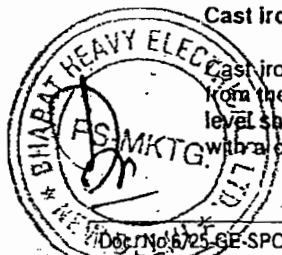
Laying of pipes shall proceed up grade of slopes. The error of grade shall not be rectified by packing up earth underneath the pipes. If required, concrete shall be used for packing. The ends of the pipes shall be kept closed to keep dirt, mud and foreign materials, out. Adequate provision shall be made to prevent floating of pipe in the event of flooding of trenches. The body of the pipe for its entire length shall rest on an even bed in the trench and places shall be excavated to receive the collar for the purpose of jointing.

##### - Jointing

The type of jointing for concrete pipes shall be with loose concrete collars and the joints shall be packed from either side with spun yarn dipped in cement slurry as specified for jointing stoneware pipes. Stiff cement mortar (1:1) shall be filled from both sides and splayed at an angle of 45° on both sides. The joint shall be adequately cured as specified for joints in stoneware pipes.

#### Cast iron rainwater pipes

Cast iron rainwater pipes fixed to the external walls shall be blocked out atleast 20 mm from the plastered surfaces by means of cast iron bobbins. The rainwater pipes at the roof level shall be fitted with a cast iron bend with a masonry bell mouth of suitable size fitted with a cast iron grating. The bottom of the down pipe shall be fitted with a shoe fixed 150



mm above ground/apron level of the building. The socket and spigots of pipes and fittings shall be jointed as specified for cast iron soil and waste pipe line.

#### Galvanised steel water supply pipes

Screwed galvanised steel pipes shall be jointed with screwed joints and screwed fittings of the same materials as that of the pipes. Any burrs remaining on the pipe ends after the treads are out shall be removed. An approved jointing compound together with a grummet of a few strands of fine yarn shall be used for jointing pipes and fittings. Any pipe threads exposed after jointing shall be painted or in the case of underground piping thickly coated with approved bituminous compound to prevent corrosion.

The depth at which the underground water supply pipe is to be laid be as shown on the drawings. The service pipe passing into or beneath the building shall be laid at least 200 mm below the ground floor level and accommodate in a previously laid sleeve in the structure where it enters the building. The space between the sleeve and the pipe at its entry into and exit from the building shall be filled with a bituminous material for a minimum of 150 mm at both ends.

Piping shall not be buried in walls or floors as far as possible. However, when unavoidable, piping shall be buried for the shortest distance necessary and adequate protection shall be provided against damage.

Galvanised steel piping shall be secured by iron or steel clamps and hooks when fixed on walls.

All pipe work shall be completely watertight and the joints shall be such that there are no projections of jointing materials or the like in the interior of pipes. Before the pipe line is commissioned, all piping and fittings shall be flushed clean.

#### High Density Polyethylene water supply pipes

All high density polyethylene pipes shall have screwed ends and shall be jointed with screwed fittings of the same materials of that of the pipes. Any burrs remaining on the pipe ends after cutting threads shall be removed. If necessary, an approved jointing compound with a few strands of fine yarn may be used for jointing pipes and fittings. All exposed high density polyethylene pipes shall be installed with PVC saddles screwed on 25 mm thick wooden blocks securely fixed on walls at suitable intervals, not exceeding 1 m. Pipe wherever installed in wall chasing shall be fixed as in the case of galvanised steel pipes.

#### PVC water supply pipes

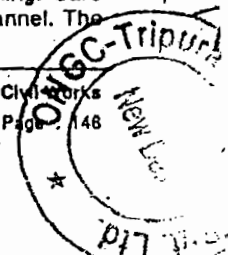
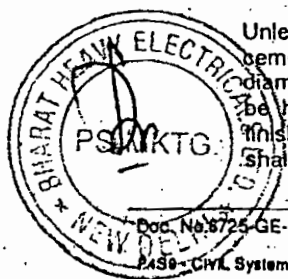
All exposed pipes shall be installed with PVC saddles screwed on 25 mm thick wooden blocks securely fixed on walls at suitable intervals, not exceeding 1 m. Pipe wherever installed in wall chasing shall be fixed as in the case of galvanised steel pipes.

#### Inspection pits and trap pits

Construction of pits shall commence only after the pipes have been laid in position to true line and levels as shown on the drawings and to the satisfaction of the Engineer.

##### - Inspection pits

Unless otherwise specified, all inspection pits shall be constructed with rubble masonry in cement mortar (1:4). Half round channels of size suitable for the inlet and outlet pipe diameters shall be formed on the floor of the pit with PCC 1:3:6. The floor of the pit shall be haunched towards the channel as shown on the drawings. Inside of pits shall be finished with cement-sand plaster (1:4) and finished smooth with cement punning. Care shall be taken to avoid unevenness on the surface and sharp bends in the channel. The



invert level after finishing shall be as shown in the drawings or as indicated by the Engineer.

- **Intercepting/master trap pits**

The pits for the glazed stoneware master trap shall be constructed as indicated in the drawings. The construction and finishing of the pit shall be haunched towards the intercepting/master trap.

- **Gully trap pits**

Gully trap pits shall be constructed as indicated in the drawings. The construction and finishing of the pit shall be as described above for inspection pits. The cast iron grating shall be set flush with the finished ground/floor level.

**Sanitary appliances**

All sanitary appliances shall be fixed in position rigidly on floor and walls as indicated in the drawings or as directed by the Engineer. All appliances shall be from the approved manufacturer and of approved colour.

- **Indian Water Closet - Squatting type (IWC)**

Squatting type water closet shall be fitted on trap and shall be jointed with gasket yarn and cement mortar. Rim of the pan shall be levelled properly and set flush with the finished floor. The pan shall be connected to PVC low level push button/lever type cistern of 10 litre capacity. The flushing cistern shall be supported on a pair of CI cantilever brackets firmly embedded in the wall in cement mortar (1:4) or screwed to wall with suitable plugs. The flush pipe from the cistern shall be 32 mm dia tested quality Chromium Plated (CP) pipe and connected to the pan inlet by means of hemp and putty joint.

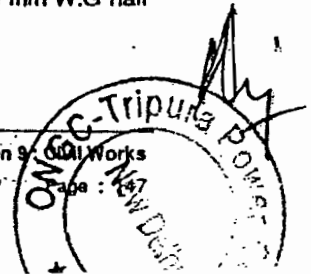
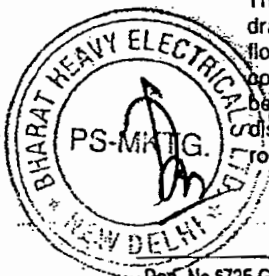
- **European Water Closet (EWC)- pedestal type**

Pedestal type water closet shall be rigidly fixed on the finished floor by means of 75 mm long brass screws with suitable plugs. The flushing cistern shall be PVC low level push button/lever type cistern of 10 litres capacity. The cistern shall be supported on a pair of cast iron or rolled steel cantilever brackets firmly fixed on wall with brass screws and suitable plugs. The flush pipe from the cistern shall be 40 mm dia chromium plated brass end and fitted to the closet by means of rubber adopter. The closet shall be provided with double plastic seat cover conforming to IS:2548 and chromium plated hinges.

- **Urinals**

Standing type urinals shall be firmly fitted on finished wall by means of 50 mm long brass screws and suitable plugs. Height of the lip from the standing point shall be as shown in the drawings. Urinals shall be fitted with automatic flush cistern of 10/15 litres (2/3 urinals) capacity. Flushing pipes shall be of CP pipes of 25 mm dia and connected to the urinal with 15 mm dia PVC connector fitted with brass cap and lining at one end. The joint to the inlet of urinal shall be neatly finished with putty joints.

The arrangement of waste pipes and discharge to the floor trap shall be as shown on the drawings or as directed by Engineer. For single urinal the discharge may be direct to the floor trap through a 40 mm dia waste pipe. For a range of urinals, the discharge may be collected in a common waste pipe of 50 mm dia leading to the floor trap. Each urinal shall be connected to the common discharge pipe by 40 mm dia waste pipes. Alternatively, the discharge from each urinal through 40 mm dia pipe shall be lead to the 100 mm W.G half round channel laid on the floor leading to the floor trap.



- **Wash hand basin**

Wash hand basin shall be fitted in position to true level on a pair of cast iron brackets plugs. The basin shall be fitted with 15 mm dia approved quality CP pillar tap and 32 mm dia waste fittings. The type of waste pipe and their connections shall be as shown in the drawings or as directed by the Engineer.

- **Sink**

Stainless steel sink shall be levelled properly and fitted in position on a pair of cast iron cantilever brackets firmly embedded in the wall in cement mortar (1:4). The sink shall be fitted with chromium plated brass waste fittings of standard size. The type of waste pipes and their connections shall be as shown on the drawings or as directed by the Engineer.

- **Other miscellaneous fittings (e.g mirror, towel rails, soap cases etc.)**

All such fittings shall be of type and sizes specified in General Technical Specification and shall be fitted in position true to line, level and plane as shown on the drawings or as directed by the Engineer.

**Water tanks**

Water storage tanks shall be of SINTEX brand or approved equivalent make, unless otherwise specified.

In case large volume tank is to be constructed, the same shall be of GI, Masonry or RCC. They shall be fitted with a ball valve of the inlet pipe. A mosquitoproof overflow pipe shall be fixed to the tank with the pipe invert about 25 mm above the top of water line. Approved type of stop valve shall be provided for every outlet pipe. All outlet and inlet pipes shall be fixed as shown in the drawings. Inside surface of galvanised steel tanks shall be painted with anti-corrosive drinking water paints.

All storage tanks, water supply fittings and pipes before being put into commission shall be disinfected with liquid chlorine by the contractor at his own cost.

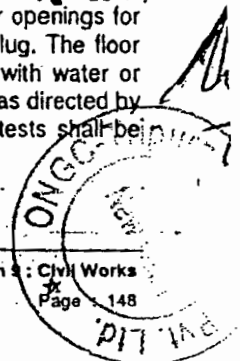
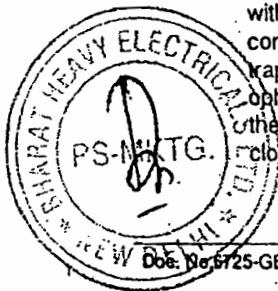
**9.5.17.6 Testing and Acceptance Criteria**

All sanitary appliances and fittings shall be inspected and tested as per the requirements of IS:1742. All defects and deficiencies detected shall be promptly rectified by the Contractor to the satisfaction of Engineer.

**Soil and waste pipe line**

On completion of laying, the cast iron, soil, waste and ventilation pipelines shall be tested by the contractor at his own cost to detect leakages and any other defects in the pipelines.

Test shall be conducted using proper apparatus with attachment for smoke making machine for applying smoke to the pipelines under pressure. Only cotton waste of brown paper soaked in cresote oil shall be used and fired to obtain dense and pungent smoke. While conducting smoke test, top of soil, waste and ventilation pipes shall be kept open till smoke starts coming out of the openings. The openings shall then be securely plugged with expanding rubber or any other approved plug. The floor traps and other openings for connecting sanitary fixtures shall be sealed with water or other approved plug. The floor traps and other openings for connecting sanitary fixtures shall be sealed with water or other approved plug. The entire pipeline shall be tested in suitable sections as directed by the Engineer. The entire length of the pipelines including all joints under tests shall be closely observed for any sign of smoke leakage.



**Galvanised steel water supply pipes**

After the laying and fixing of all galvanised steel water supply pipes and fittings are completed, the line shall be slowly and carefully charged with water to a test pressure of 5 kg per sq cm or the specified working pressure plus 50% as may be prescribed by the Engineer. Care shall be taken that air in pipelines is completely exhausted while filling the pipelines with water. This pressure shall be maintained for at least one hour, unless otherwise specified.

**9.5.18 Tank Pads****9.5.18.1 Scope**

This specification covers the requirements in respect of materials, workmanship and quality for bituminous works, crushed rock ring and ring walls for tank pads.

**9.5.18.2 Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their later editions published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder :

IS:383	Coarse and fine aggregating from natural sources for concrete.
IS:2720	Part VII - determination of water content-dry density relation using light compaction.
IS:2720	Part VIII - determination of water content - dry density relation using heavy compaction.
IS:2720	Part IV - grain size analysis
IS:1478	Classification and identification of soils for general engineering purposes.
IS:803	Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded oil storage tanks.
IS:73	Paving Bitumen

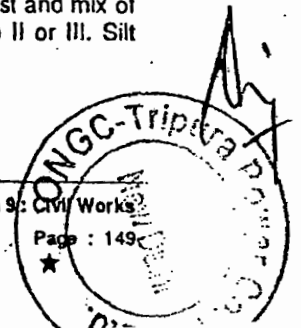
In addition to the above, other codes referred in sections 10.4.3 & 10.4.5 shall also apply.

**9.5.18.3 Materials****Bitumen**

Bitumen used for anti-corrosive layer shall be of grade 80/100 or equivalent.

**Sand**

Sand shall be clean, dry, coarse, hard, angular free from coatings of clay, dust and mix of vegetable and organic materials and shall conform to IS:383 grading Zone II or III. Silt content shall not be more than 5%.



**Moorum**

Moorum for filling shall consist of coarse and granular moorum containing not more than 20% cohesive fines such as clay (grain size less than 0.074 mm). The moorum shall be 20 mm and down size grading and shall be taken from approved quarries.

**Stone Aggregates for crushed Rock Ring**

Stone aggregates for the crushed rock ring shall be 50 mm and down grade size and shall be of granite or such other approved materials.

**Stone chippings for premix carpet**

Stone chippings for premix carpet shall be hard blue granite or approved locally available stone. The grading shall be normally 12 mm down size and 6 mm down size in the ratio 3:2 respectively.

**Cement, steel and aggregates for R.C.C. works in dyke wells**

The material specifications for the above shall be the same as in Clause 9.4.5.

**9.5.18.4 Workmanship****Sub Grade Preparation**

The surface of the natural soil exposed at the bottom of excavated pit shall be thoroughly compacted by rolling arising 8 - 10 ton road roller or other means as directed by Engineer-in-charge to obtain 95% of maximum laboratory/ standard proctor dry density for the soil as per IS:2720 part VII. The minimum number of passes shall be five. The rolling shall also be done outside the tank pad area for atleast 1.5 m beyond the edge of tank pad. Relevant clauses in Section for Earthwork shall also apply.

**Sand/Moorum Filling**

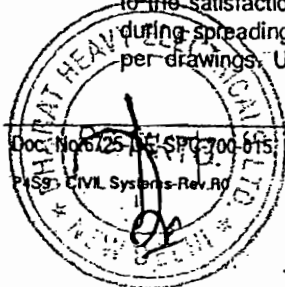
The sand/moorum shall be spread in layers not exceeding 15 cm in loose thickness over the areas. Each layer shall be uniform in density, quality of materials and moisture content before compaction. The moisture content shall be within two percent (2%) of optimum moisture content (OMC) on the dry side of OMC as per IS:2720. Compaction of each layer shall be done by mechanical means as per directions of Engineer. Only inaccessible reaches shall be worked manually.

Each layer shall be uniformly compacted to obtain 95% standard proctor density or 85% relative density. If the material fails to achieve the required density, the layer should be reworked with necessary alteration in the composition, so that the required compaction is obtained.

Further layer shall be placed only after the layer has been compacted to the required density. The finished surfaces must be dressed to required grade and slope. Excess material must be removed from compaction site.

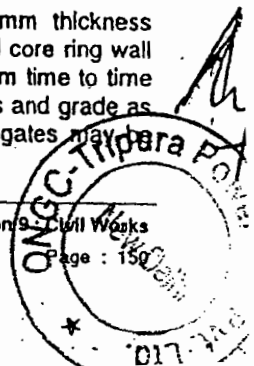
**Crushed Rock Ring**

The stone aggregates for the above shall be laid in layers of 150 mm thickness (compacted thickness) and each layer shall be compacted to obtain a hard core ring wall to the satisfaction of Engineer-in-charge. The surface shall be checked from time to time during spreading and compaction to ensure a finished surface true to levels and grade as per drawings. Use of fine aggregates such as sand or finer stone aggregates may be



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required to fill voids and pockets to obtain a uniform compacted hard core. Over the final compacted layer of stone aggregate, sand shall be evenly spread and compacted by tamping/rolling.

#### Anti Corrosive Layer

Anti corrosive layer shall consist of screened coarse sand mixed with 80/100 bitumen or equivalent, 8 to 10% by volume. The bitumen shall be treated to a temperature of 75°C to 190°C with 3% kerosene if required and sand shall be thoroughly mixed with it in mixing drum to give uniform mixture and shall be laid over the compacted surface of the pad in line, grade and levels as shown in the drawings or as directed by the Engineer. Bitumen shall not be treated beyond the temperatures limits given above. The layer shall be tamped to form hard mass of uniform compacted thickness specified. The anticorrosive layer shall be made in one layer for a 50 mm thickness. For higher thickness it should be laid in two layers after application of a tack coat of bitumen. These layers shall be finished to grade as specified.

#### Premix carpet

The crushed rock ring where provided and the areas on which the pre-mix is to be laid (generally the areas exposed to sun & rain) shall be thoroughly cleaned of all dust and loose materials. On the cleaned surface a tack coat at the rate of 1.0 Kg/m<sup>2</sup> of hot bitumen shall be uniformly applied by sprayers. The applied binder shall be evenly brushed. The binder bitumen 80/100 shall be heated to the temperature of about 190°C with 3% kerosene, if required and mixed with stone chippings at the rate of 6.1 m<sup>3</sup> for 400 Kg of bitumen for 100 sq. m of surface of 50 mm thick carpet. Mixing shall continue until the aggregate is well coated.

The pre-mix carpet shall be laid in two layers of 30 mm and 20 mm. After compacting and laying the first layer of 30 mm, a tack coat of hot bitumen at the rate of 1 Kg/m<sup>2</sup> shall be uniformly applied to the surface by means of sprayer and second layer of 20-mm thick shall be laid, tamped and compacted to the satisfaction of the Engineer. Sand shall be spread on the final surface at the rate of 0.5 m<sup>3</sup>/100 m<sup>2</sup>.

#### Reinforced Concrete Works for Ring Wall

Reinforced concrete works shall be done as per specifications laid down in Section 9.4.5.

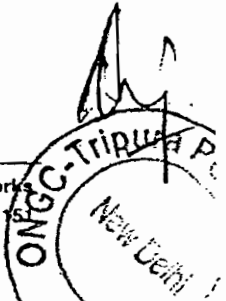
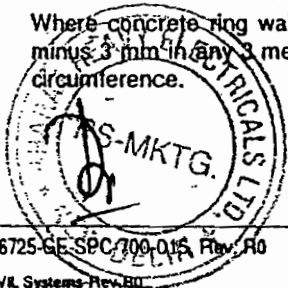
The ring wall shall be cast in quick succession and completed within a period of maximum 7 days. It is desirable that it is cast in alternate lengths along the perimeter at first keeping the horizontal reinforcements independent on the next cast panels. Intermediate panel lengths shall be cast after 3 days to provide some relief from shrinkage strain.

#### 9.5.18.5 Tolerances

The top surface of tank pad shall be to true level & line within the tolerance limit specified below.

Where concrete ring wall is provided, the differential level shall be within plus or minus 3 mm in any 10 metres of circumference and within plus or minus 6 mm in total circumference.

Where concrete ring walls are not provided, the differential level shall be within plus or minus 3 mm in any 3 metres of circumference and within plus or minus 12 mm in the total circumference.



**9.5.19 Water Bound Macadam (WBM), Roads****9.5.19.1 Scope**

This specification covers the requirement in respect of materials, workmanship and quality for road works like sub-grade preparation, sub-base layer, water bound macadam, drains, pipe culverts etc.

**9.5.19.2 Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

Specification for road and bridge works of Ministry of shipping & Transport (Roads wing)  
Published by IRC.

IRC -19 Standard specification and code of practice for Water Bound Macadam

IRC SP 11 Hand Book of quality control for construction of roads and runways

IS: 458 Specification for concrete pipes

IS: 783 Code of practice for laying of concrete pipes

IS: 2720 Methods of test of soil (All parts)

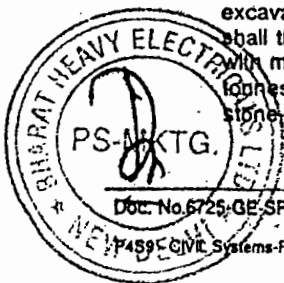
**9.5.19.3 Sub Grade****Excavation**

After the earthwork in cutting, and the earthwork in embankments have been done properly upto the final road level with gradients and camber as per drawings and proper consolidation of the filling is completed, earthwork in box cutting shall be taken in hand. Before starting of Box cutting, the Contractor shall obtain Engineer's approval of cutting and embankment work.

The surface of the formation for a width equal to that of the sub-base course shall be properly prepared before any further courses are laid. Surface shall be cut to a depth below the ground level equal to depth of sub-base course due allowance being made for compaction. Preparation of sub-grade also includes removal of any and all foreign substance accumulation and removing undulations upto 150 mm by filling and cutting as required. The sub-grade shall be dressed parallel to the finished profile.

The excavated spoils shall be transported and utilized in filling of low areas or as directed by the Engineer. The filling shall be done in layers or as directed by the Engineer. The filling shall be done in layers of 150 mm and clods and lumps shall be broken and consolidation done to the satisfaction of the Engineer.

In case of presence of weak soil-pockets below the formation, the Contractor shall excavate and remove such soil to an extent as instructed by the Engineer. Extra depth shall then be filled up with 38 mm down stone-metal and voids in metal shall be filled up with moorum. Then, the filling shall be rammed and rolled uniformly with a road-roller of 8 tonnes minimum weight. These operations of removing weak soil pockets and filling with stone-metal shall be done by the Contractor.



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If, by mistake the depth of box cutting is made more than required, the Contractor shall make up the extra depth by metal consolidation, as specified above, at his own cost.

After the top layer/WBM course is laid and compacted, the existing surface at the shoulders of the road must be scarified. Fresh quantity of approved earth must be extracted from the surplus earth obtained by box cutting spreading in layers for building up the berms. The layer of earth must be compacted by atleast three passes of 8 - 10 tonne rollers. The edges must be well compacted by suitable means to prevent edge slips and the work properly trimmed and dressed.

#### Rolling

After the box cutting is completed, the sub-grade shall be compacted with powered road roller 8-12 tonnes. The roller shall run over the sub-grade till the soil is evenly and densely compacted, to achieve a dry density of not less than 95% of maximum density as obtained from standard proctor compaction test. There shall be a minimum of five (5) roller passes. All the undulations on the surface which develop due to rolling shall be made good with earth and quarry spills as approved by Owner and the sub-grade re-rolled. The top of the sub grade shall be dressed evenly to the required camber and necessary drainage arrangement at the time of rolling shall be provided. Care shall be taken to avoid excessive rolling of the formation. If, after rolling the formation is higher than required, the excess earth shall be removed by carefully cutting and dressing and the formation shall be rolled as specified above. In case after rolling the formation is depressed below the required level, the Contractor shall continue the process of filling and rolling as above till the correct level is attained upto a limit as decided by the Engineer at Contractor's cost.

#### 9.5.19.4 Soling (Sub-Base)

This work shall consist of laying and compacting rubbles or boulders on prepared sub-grade in accordance with the requirements of this specification. The material shall be laid in one or more layers as shown on the drawings and according to lines, grades and cross sections shown on the drawings or as directed by the Engineer.

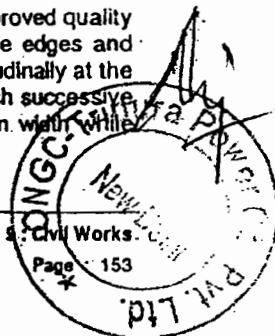
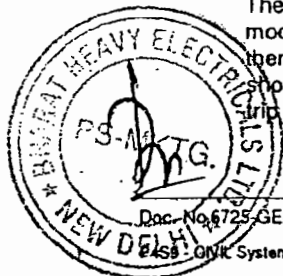
#### Materials

The materials to be used for the work shall be rubbles or boulders and gravel from approved quarries. The maximum size of stone shall be 150 mm. The length and breadth of stone shall not be more than twice of its depth. The stones shall be hard, tough and durable and free of earth, loam or vegetable matter. The flaky material shall not be used.

#### Construction

The soling shall be laid as per the cross section as shown on the drawing and the finished thickness after consolidation shall be as directed by the Engineer. The boulders shall be laid flat with their broad faces resting over the sub-grade to have good seating. The stones shall be hand packed as close as possible and bedded firmly. The voids in the soling shall be filled with stone chips and small stones and hammered and wedged into position. Gauge pegs shall be driven into indicate the thickness of the stones to be laid. Any hollows formed during rolling shall be filled in with spills during the process of consolidation so as to conform with the gradient, camber and cross section of the road and leave an even finished solid surface.

The soling shall be rolled by a 8 to 12 tons power roller after blinding with approved quality moorum. The shoulder shall be rolled first to wedge the stones firmly at the edges and then rolling shall proceed towards the centre. The rolling shall be done longitudinally at the shoulder and worked towards the centre of the pavement overlapping on each successive strip by at least one-half of the width of the roller while starting and 300 mm width while



finishing. In case of super elevated strips, the rolling shall commence from the inner edge and proceed towards the outer edge.

The roller shall be operated at the lowest speed possible. The speed in any case shall not be greater than 3 km per hour. Rolling shall be continued till a satisfactory surface is obtained. Wherever use of power roller is not feasible, suitable hand roller may be used as per instructions of the Engineer.

The soling if not done as per the specification, if instructed by the Engineer, the whole soling over the defective portion shall be taken out, re-laid and compacted with a road roller as specified earlier, by the Contractor at his own cost.

#### 9.5.19.5 Sand-Gravel Sub-Base

The work shall consist of laying and compacting of a mix of sand and gravel in specified proportion over a prepared sub-grade to the required lines, grades and cross-section in layers as per requirement of this specification.

##### Materials

Sand shall be medium hard, strong, free from organic and deleterious matter and shall be from a source approved by the Engineer. Sea sand shall not be approved.

Gravel shall be clean, well graded and free from any vegetation organic clay or other materials and shall be from a source approved by the Engineer.

##### Construction

The sand and gravel shall be mixed thoroughly in specified proportions by approved means. The moisture content shall be brought to within two (2) percent of the optimum moisture content for the mixed materials as per IS:2720 (Part viii).

The sand gravel mix shall be spread over the prepared sub-grade in layer not exceeding 200 mm thick (uncompacted thickness) and compacted by power rollers (8-10 tonnes) to achieve 85% relative density. The layer shall be compacted to the required camber, slope and line.

Further layer shall be placed only after the layer already laid has been compacted to the required density and approved by the Engineer based on the test results. The finished surface shall be dressed to required camber and level and excess material removed and disposed off by the Contractor at his own cost as instructed by the Engineer.

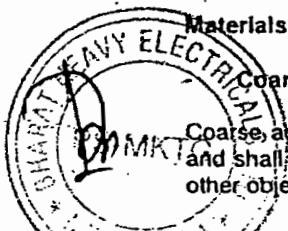
#### 9.5.19.6 Water Bound Macadam (Sub-Base/Base Coarse)

Water bound macadam shall consist of clean, crushed aggregates mechanically interlocked by rolling and bonded together with screenings, binding material, where necessary and water, laid on a prepared surged or sub-base, as the case may be, and finished in accordance with the requirements of these specifications and in conformity with the lines, grades and cross-sections shown on the drawings or otherwise directed by the Engineer.

##### Materials

##### Coarse Aggregate

Coarse aggregate shall be of crushed blue granite. Aggregate shall be hard and durable and shall be free from excess of flat, elongated, soft and dis-integrated particles, dirt and other objectionable matter and shall be from a source approved by the Engineer.



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Crushed aggregate shall meet the following requirements :-

- i) Flat or elongated pieces shall not be more than 15%.
- ii) Los Angels Abrasion value shall not be more than 40% or Aggregate Index value shall not be more than 30%. Coarse aggregate shall be graded as follows :

Size Range	IS Sieve designation	Percentage passing by weight
63 - 40 mm	80 mm	100
	63 mm	90 - 100
	50 mm	35 - 70
	40 mm	0 - 15
	20 mm	0 - 5

Following test shall be conducted on samples of aggregate :

- i) Sieve analysis.
- ii) Impact tests
- iii) Water absorption test - Maximum water absorption shall be 1%
- iv) Wetting and drying - The samples shall be subjected to alternate wetting and drying for 3 days and shall not show signs of disintegration.

- Screenings

Screenings shall generally be of same material as the coarse aggregate and meet the following gradings :

Size of screening	IS Sieve designation	Percentage passing by weight
10 mm	10 mm	100
	4.75 mm	85 - 100
	150 microns	10 - 30

Where non-plastic material like moorum is specified, the liquid limit and plastic limit of such material shall be below 20 and 6 respectively and the fraction passing 75 microns sieve shall not exceed 10%.

- Binding Materials

Gravel of suitable plasticity available from local quarries may be used as binding materials and the same shall be approved by the Engineer.

When sample of the binding material is wetted and squeezed in hand the following characteristics shall be noted :

- i) The material shall be extremely gritty.
- ii) It can be formed into definite shapes that retain their form even when dried.
- iii) When the wetted sample is patted in the palm of the hand it will compact into a dense cake that cannot be penetrated easily with a blunt stick.

#### Construction

##### - Preparation of Base

The sub-grade /sub-base to receive the water bound macadam coarse shall be prepared to the specified grade and camber and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm.

##### - Inverted Choke

If the water bound macadam is to be laid directly over the sub-grade, without any other intervening pavement course, a 25 mm course of screenings shall be spread on the prepared sub-grade before application of the coarse aggregate is taken up.

##### - Spreading Coarse Aggregate

The coarse aggregates shall be spread uniformly upon the prepared surface. The spreading shall be done from stockpiles along the side of the roadway or directly from vehicles. In no case shall the aggregate be dumped in heaps directly on the surface prepared to receive the aggregate nor shall hauling over the uncompacted or partially compacted base be permitted.

The surface of the aggregates spread shall be carefully checked with template and all high or low spots remedied by removing or adding aggregate as may be required. No segregation of large or fine particles shall be allowed and the coarse aggregate as spread shall be of uniform gradation with the pockets of fine material.

The coarse aggregate shall not normally be spread more than three (3) days in advance of the subsequent construction operations.

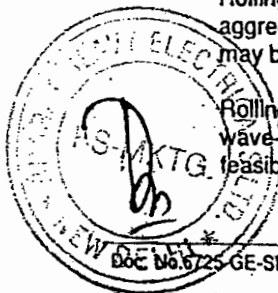
##### - Rolling

Immediately following the spreading of the coarse aggregate, rolling shall be started with three wheeled power rollers of 8 to 10 tonne capacity or tandem-roller or vibratory rollers of approved type. The weight of the roller shall depend upon the type of the aggregate and be indicated by the Engineer.

Except on superelevated portions where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre. First the edge/ edges shall be compacted with roller running forward and backward. The roller shall then move inwards parallel to the centre line of the road, in successive passes uniformly lapping preceding tracks by at least one half width.

Rolling shall continue until the aggregates are thoroughly keyed and the creepage of aggregates ahead of the roller is no longer visible. During rolling slight sprinkling of water may be done, if necessary.

Rolling shall not be done when the sub-grade is soft or yielding or when it causes a wave-like motion in the sub-grade or sub-base course. Wherever use of power roller is not feasible, suitable hand roller may be used as per the instructions of the Engineer.



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The rolled surface shall be checked transversely and longitudinally with templates. If irregularities noticed, which exceed 12.5mm when tested with a 3m straight edge, the surface shall be loosened and aggregates added or removed as required and re-rolled until the entire surface conforms to desired camber and grade. In no case shall use of screenings be permitted to make up depressions.

#### - Applications of Screenings

After the coarse aggregate has been rolled, screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motion of hand shovels or by mechanical spreaders, or directly from trucks. Trucks operating for spreading the screenings shall be so driven as not to disturb the coarse aggregate.

The screenings shall be applied at a slow and uniform rate (in three or more application) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms, hand brooms or both. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregate.

The spreading, rolling and brooming of screenings shall be carried out in only such lengths of the road which would be completed within one day's operation.

#### - Sprinkling and Grouting

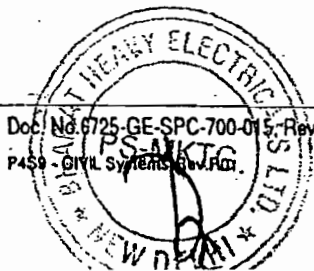
After the screenings have been applied, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into voids and to distribute them evenly. The sprinkling, sweeping and rolling operations shall be continued, with additional screening as necessary, until the coarse aggregate has been thoroughly keyed, well-bonded and firmly set in its full depth and a grout has been formed of screening. Care shall be taken to see that the base or sub-grade does not get damaged due to the addition of excessive quantities of water during construction.

#### - Application of Binding Material

After the application of screenings, the binding material where it is required to be used shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water, the resulting slurry swept in with hand brooms, or mechanical brooms to fill the voids properly, and rolled during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling of voids, forms a wave ahead of the wheels of the moving roller.

#### - Setting and Drying

After the final compaction of water bound macadam course, the road shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings or binding materials as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam has set. The Engineer shall have the discretion to stop hauling traffic from using the completed water bound macadam course if in his opinion it would cause excessive damage to the surface.

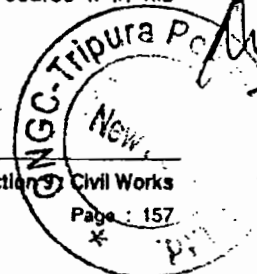


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- **Second Layer of WBM (where specified)**

Before laying the second layer of WBM, the surface shall be scarified and reshaped to the required camber and profiles and all ruts, depressions, pot holes etc. made good. The second layer shall be laid after the surface preparation is approved by the Engineer.

The specification for second layer of WBM shall be similar to the first.

**9.5.19.7 Pipe Culverts**

**Materials**

The drainage pipes unless otherwise shown on drawings or instructed by the Engineer, shall be made of RCC (Hume pipe) and shall be either Class NP2 or NP3.

Pipe culverts shall be made of reinforced concrete pipe (Hume Pipe) and shall be of class NP2 or NP3 as decided by the Engineer or shown in the drawing. All pipes shall meet the requirements of IS:458 and shall be procured from approved manufacturers with collars as per manufacturers standard specifications. The Bidder shall specifically mention the particular manufacturer's product he proposes to use.

Cement shall be Ordinary Portland Cement as per IS:269.

Aggregate shall be as per IS:383 - Maximum size shall not exceed one third the thickness of the pipe or 20 mm whichever is smaller. For bedding concrete for laying the pipes, the maximum size of aggregate shall be 38 mm.

Fine aggregate for concrete shall be as per IS:383.

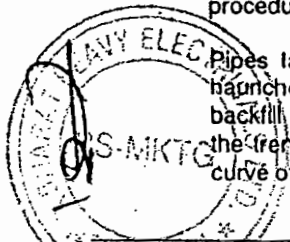
**Laying of Pipes**

Laying of Hume pipes and collars shall be done as per IS:783. Pipes shall be laid either in trenches or on supports as per drawing and/or Engineer's instructions. All pipe sections and collars shall be inspected carefully for defects before laying in the trenches. Broken or defective pipe shall not be used and shall be properly marked and removed from site as soon as the defects are detected. Pipes shall be laid true to line and grade as specified in the drawings and/or Engineer's instruction. The bedding of the pipes shall be 'First class bedding' or ordinary bedding as per IS:783. The profile of cutting of trenches, free working space provided on each side of the pipe, etc. shall be decided at site by the Engineer as per site condition. Side slope, shoring, balling out water etc. as required shall be done by the Contractor. Side slips, if there be any, shall be removed by the Contractor. After laying of the pipes are completed, backfilling of the trenches shall be done in layers of 150 mm, clods and lumps broken, watered and compacted with iron rammers to the satisfaction of the Engineer. The surplus spoils shall be transported and filled in low areas within the plant area, as instructed by the Engineer. The filling shall be done as per specification.

All pipes and fittings shall be gradually lowered into the trench or placed on the supports by approved means taking due care not to damage them.

Under no circumstances the pipes shall be dropped into the trench or on supports from a height. The joints of pipes shall be grouted with 1:2 cement - sand mortar and the procedure of jointing shall be as per IS:783.

Pipes laid in trenches in earth shall be bedded evenly and firmly and as far up the haunches of the pipes as consistent with the load expected to be transmitted from the backfill through the pipe to the bed. This shall be done either by excavating the bottom of the trench to fit the curve of the pipe or by compacting the earth under and around the curve of the pipe to form an even bed.



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Where the pipe is laid in trench in rock, hard clay, shale or other hard materials, the space below the pipe shall be excavated and replaced with an equalising bed of concrete (1:4:8 mix), sand or compacted earth as approved by the Engineer. In no place shall the pipe be laid directly on such hard material.

If end protection wall is shown in drawing, the wall shall be constructed with first class quality locally available bricks from approved source. All civil works connected with the protection work, like concrete, brick masonry, plastering etc. shall be done as per relevant Indian Standards and in accordance with approved construction drawings. All materials used shall also conform to Indian Standards.

#### 9.5.20 Bitumen Roads

##### 9.5.20.1 Scope

This specification covers the requirement in respect of materials, workmanship and quality for bitumen roads like bitumen macadam, premix carpet etc. Moreover, for specification for base course, sub-base course of roads, the technical specification C-13 (Technical Specification for road works construction roads) shall be referred.

##### 9.5.20.2 Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by Indian Road Congress and Bureau of Indian Standards shall govern in respect of design, workmanship, quality and properties of materials and method of testings.

Some of relevant available codes are listed here under.

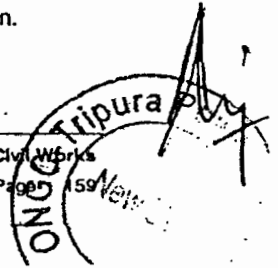
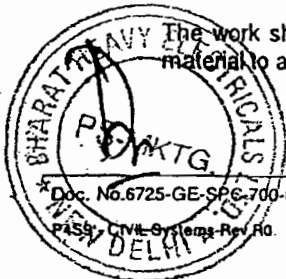
IRC - 47	Standard specification and code of practice for bitumen road.
IRC - 48	Standard specification for bitumen roads surface dressing using pre coated aggregates.
IRC - SP - 11	Hand book of quality control for construction for roads and runaways.
IS:73	Specification for paving bitumen.
IS:217	Specification for cut back bitumen.
IS:454	Specification for digboi type cut back bitumen.
IS:1200	Method of measurement for road work (Part-17) including air field pavements.

##### 9.5.20.3 Execution

###### Tack Coat

###### Description

The work shall consist of application of a single coat of low viscosity liquid bituminous material to an existing road surface preparatory to another bituminous construction.



**Materials**

**Binder:** The binder used for tack coat shall be bitumen of a suitable grade as directed by the Engineer and conforming to IS:73, 217 or 454, as applicable, or any other approved cutback.

**Construction Operations**

**Preparation of Base**

The surface on which the tack coat is to be applied shall be thoroughly swept and scraped clean of dust and any other extraneous material before the application of the binder.

**Application of Binder**

Binder shall be heated to the temperature appropriate to the grade of bitumen used and approved by the Engineer and sprayed on the base at the rate specified below. The rate of spread in terms of straight-run bitumen shall be 5 kg. per 10 square metre area for an existing bitumen treated surface and 10 kg per 10 square metre area for an untreated water bound macadam surface. The binder shall be supplied uniformly with the aid of sprayers.

The tack coat shall be applied just ahead of the oncoming bituminous construction.

**Semigrout (Bituminous Macadam Binder Course)**

This work shall consist of construction, in a single course, 115 mm thickness of compacted crushed aggregates permixed with a bituminous binder, laid immediately after mixing, on a base prepared previously in accordance with the requirements of these specifications and in conformity with the lines, grades and cross sections shown on the drawings or directed by the Engineer.

**Materials**

**Binder**

The binder shall be straight run bitumen of a suitable grade as directed by the Engineer complying with IS:73.

The aggregates shall satisfy the physical requirements set forth in Table-I.

**Table I**  
**Physical Requirements of Aggregates for Bituminous Macadam**

Los Angeles Abrasion *	IS:2386	35% Maximum (Part IV)
Aggregate Impact Value *	IS:2386	30% Maximum (Part IV)
Flakiness Index	IS:2386	35% Maximum
Stripping Value	IS:6241	25% Maximum
Water Absorption	IS:2386	2% Maximum value

Aggregates may satisfy requirements of either of the two tests

The aggregates for bituminous macadam for different thickness shall conform to the grading A or B given in Tables II & III.

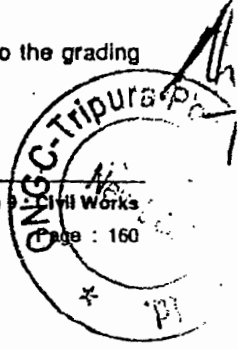


Table II

Aggregates Grading for 115 Mm Compacted Thickness  
of Bituminous Macadam

Sieve Designation	Percent by weight passing the sieve	
	Grading A	Grading B
63 mm	100	
50 mm	90-100	
40 mm	35-65	100
25 mm	20-40	70-100
20 mm	-	50-80
12.5 mm	5-20	-
4.75 mm	10-30	-
2.36 mm	-	5-20
75 micron	0-5	0-4

Table III

Aggregates Grading for 50 Mm Compacted Thickness  
of Bituminous Macadam

Sieve Designation	Percent by weight passing the sieve	
	Grading A	Grading B
50 mm	100	
40 mm	90-100	
25 mm	50-80	100
20 mm	-	70-100
12.5 mm	10-30	-
10 mm	35-60	-
4.75 mm	-	15-35
2.36 mm	-	0-20
75 micron	0-5	0-4

## - Proportioning of Materials

The binder content for premixing shall be 3.5 and 4.0 percent by weight of the total mix for aggregate grading A and B respectively, except when otherwise directed by the Engineer.

The quantities of aggregates to be used shall be sufficient to yield the specified thickness after compaction.

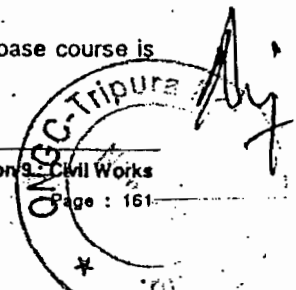
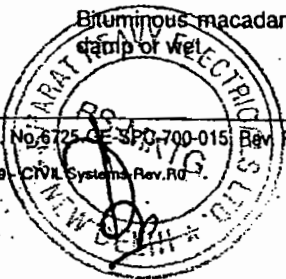
## - Variation in Proportioning of Materials

The Contractor shall have the responsibility for ensuring proper proportioning of materials and producing a uniform mix. A variation in binder content of  $\pm 0.3$  percent by weight of total mix shall, however, be permitted for individual specimens taken for quality control tests.

## Construction of Operation

## - Weather and Seasonal Limitations

Bituminous macadam shall not be laid during rainy weather or when the base course is damp or wet.



- **Preparation of Base**

The base on which bituminous macadam is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross sections as directed by the Engineer. The surface shall be thoroughly swept and scraped clean and free from dust and foreign matter.

- **Tack Coat**

A tack coat shall be applied over the base.

- **Preparation and Transport of Mix.**

Hot mix plant of adequate capacity shall be used for preparing the mix.

The temperature of binder at the time of mixing shall be in the range 150°C - 165°C and that of aggregates in the range 125°C - 150°C provided that the difference in temperature between the binder and aggregate at no time exceed 25°C.

Mixing shall be thorough to ensure that the homogenous mixture is obtained in which all particles of the aggregates are coated uniformly.

The mixture shall be transported from the mixing plant to the point of use in suitable vehicles. The vehicles employed for transport shall be clean and be covered over in transit if so directed by the Engineer.

- **Spreading**

The mix shall be spread immediately after mixing by means of a self propelled mechanical paver with suitable screeds capable of spreading, tamping and finishing the mix to the specified lines, grade and cross sections. However, in restricted locations and in narrow widths, where the available plants cannot operate in the opinion of the Engineer, he may permit manual laying of the mix.

The temperature of mix at the time of laying shall be in the range 110 Deg - 135 Deg C.

In multilayer construction, the longitudinal joint in one layer shall offset that in the layer below by about 150 mm. However, the joint in the topmost layer shall be at the centre line of the pavement.

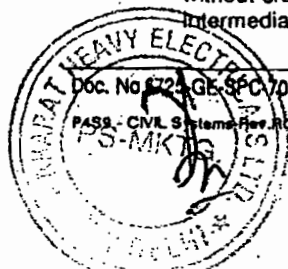
Longitudinal joints and edges shall be constructed true to the delineating lines parallel to the centreline of the road. All joints shall be cut vertical to the full thickness of the previously laid mix and the surface painted with hot bitumen before placing fresh material.

- **Rolling**

After the spreading of mix, rolling shall be done by 8 to 10 tonne power rollers or other approved plant. Rolling should start as soon as possible after the material has been spread. Rolling shall be done with care to keep from unduly roughening the pavement surface.

Rolling of the longitudinal joint shall be done immediately behind the paving operations. After this, the rolling shall commence at the edges and progress towards the centre longitudinally except that on super-elevated portions, it shall progress from the lower to the upper edge parallel to the centre line of the pavement.

The initial or breakdown rolling shall be done as soon as it is possible to roll the mixture without cracking the surface or having the mix pick up on the roller wheels. The second or intermediate rolling shall follow the breakdown rolling as closely as possible and be done



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while the paving mix is still at a temperature that will result in maximum density. The final rolling shall be done while the material is still workable enough for removal of roller marks.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding fresh material. The rolling shall then be continued till the entire surface has been rolled to compaction, there is no crushing of aggregate and all roller marks have been eliminated. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. The roller wheels shall be kept damp if necessary to avoid the bituminous material from sticking to the wheels and being picked up. In no case shall fuel lubricating oil be used for this purpose.

Rolling operations shall be completed in every respect before the temperature of the mix falls below 80 deg C.

Rollers shall not stand on newly laid material while there is a risk that it will be deformed thereby. The edges along and transverse of the bituminous macadam laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it. Wherever use of power roller is not feasible, suitable hand roller may be used as per the instructions of the Engineer.

The bituminous macadam shall be provided with final surfacing without any delay. If there is to be any delay, the course shall be covered by a seal coat before allowing any traffic over it.

#### Open Graded Premix Carpet

##### - Description

This work shall consist of laying and compacting an open-graded carpet of 5 cm thickness in a single course composed of suitable small sized aggregates premixed with a bituminous binder on a previously prepared base, to form a wearing course, in accordance with the requirements of these specifications.

##### - Materials - Binder

The binder shall be bitumen of a suitable grade, as directed by the Engineer and satisfying the requirements of IS:73, 217, 454 or other approved cutback as applicable.

##### - Aggregate

The aggregate shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They shall be obtained by crushing rock and be free of elongated and flaky pieces, soft and disintegrated materials and vegetable or other deleterious matter. They shall preferably be hydrophobic type.

The aggregates shall satisfy the quality requirements set forth in Table I except that the Flakiness Index shall be limited to a maximum of 30%.

##### - Proportioning of Materials

The materials shall be proportioned as per quantities given in Table IV.

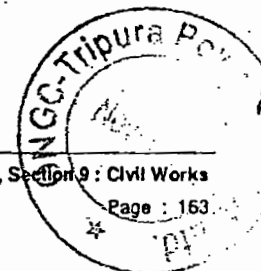


Table IV

Quantities of Materials Required for 10 sq.m.  
of Road Surface for 5 cm Thick open-graded

## Premix Carpet

## Aggregates of carpet

- |  |           |
|--|-----------|
| a) Stone chippings - 12 mm size; passing<br>20 cm sieve and retained on 10 mm sieve    | 0.18 cu.m |
| b) Stone chippings - 10 mm size; passing<br>12.5 mm sieve and retained on 6.3 mm sieve | 0.09 cu.m |

## Binder for premixing (quantities in terms of straight run bitumen)

- |   |         |
|---|---------|
| a) For 0.18 cu.m of 12 mm size stone<br>chippings at 52 kg per cu.m | 9.5 kg. |
| b) For 0.09 cu.m of 10 mm size stone<br>chippings at 56 kg per cu.m | 5.1 kg  |

Total	14.6 kg
-------	---------

## Construction Operation

## - Weather and Seasonal Limitations

Open graded premix carpet shall not be laid during rainy weather or when the base course is damp wet or when the atmospheric temperature in shade is 16 deg C or below :

## - Preparation of Base

The underlying base on which the bituminous carpet is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross section in accordance with Table V as directed by the Engineer. The surface shall be well cleaned by removing caked earth and other foreign matter with wire brushes, sweeping with brooms and finally dusting with sacks as necessary.

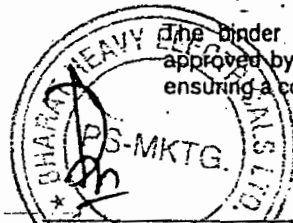
## - Tack Coat

A tack coat complying with relevant clause above shall be applied over the base preparatory to laying of the carpet. Application of tack coat shall, however, not be necessary when the laying of carpet follows soon after the provision of the bituminous course.

## - Preparation of Premix

Mixers of approved type shall be employed for mixing the aggregates with the bituminous binder.

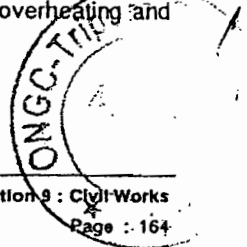
The binder shall be heated to the temperature appropriate to the grade of bitumen approved by the Engineer, in boilers of suitable design avoiding local overheating and ensuring a continuous supply.



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The aggregates shall be dry and suitably heated to a temperature as directed by the Engineer before these are placed in the mixer. After about 15 seconds of dry mixing, the heated binder shall be distributed over the aggregates at the rate specified.

The mixture of binder with chipping shall be continued until the chippings are thoroughly coated with the binder. The mix shall be immediately transported from the mixer to the point of use in suitable vehicles or wheel barrows. The vehicles employed for transport shall be clean and be covered over in transit if so directed.

- Spreading and Rolling

The premixed material shall be spread on the road surface with rakes to the required thickness and camber or distributed evenly with the help of a drag spreader, without any undue loss of time. The camber shall be checked by means of camber boards and inequalities evened out. As soon as sufficient length of bituminous material has been laid rolling shall commence with 8 to 10 tonne power rollers, preferably of smooth wheel tandem type, or other approved plant. Rolling shall begin at the edges and progress toward the centre longitudinally, except that on the superelevated portions it shall progress from the lower to upper edge parallel to the centre line of the pavement.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding premixed materials. Rolling shall then be continued until the entire surface has been rolled to compaction and all the roll marks eliminated. In each pass of the roller preceding track shall be overlapped uniformly by at least 1/3 width. The roller wheels shall be kept damp to prevent the premix from adhering to the wheels and being picked up. In no case shall fuel/lubricating oil be used for this purpose. Wherever use of power roller is not feasible, suitable hand roller may be used as per the instructions of the Engineer.

Rollers shall not stand on newly laid material while there is a risk that it will be deformed thereby.

The edges along and transverse of the carpet laid and compacted earlier shall be cut to their full length so as to expose fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it.

- Seal Coat

A seal coat conforming to relevant clause shall be applied to the surface immediately after laying the carpet. No traffic shall be allowed on the road till the seal coat has been placed.

Seal Coat

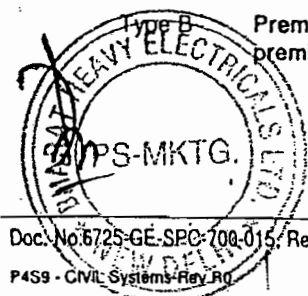
- Description

This work shall consist of application of a seal coat (Type-B) for sealing the voids in a bituminous surface laid to the specified levels, grade and camber.

Seal coat shall be of two types as given below :

Type A Liquid seal coat comprising of an application of the bituminous binder followed by a cover of stone chippings.

Type B Premixed seal coat comprising of a thin application of fine aggregate premixed with bituminous binder.



**Materials****- Binder**

The bidder shall be bitumen of a suitable grade as directed by the Engineer and conforming to the requirements of IS:73, 217, 454 as applicable or any other approved cutback.

The quality of binder to be utilized, in terms of straight run bitumen shall be 9.8 kg and 6.8 kg per 10 square metre area for Type A and Type B seal coat respectively.

**- Stone Chippings for Type A Seal Coat**

The stone chippings shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They shall be free of elongated or flaky pieces, soft or disintegrated stone, vegetable or other deleterious matter. Stone chippings shall be of 6 mm size defined as 100 percent passing through 10 mm sieve and retained on 2.36 mm sieve. The quantity used for spreading shall be of 0.09 cu.m. per 10 sq.m. area. The chippings shall satisfy the quality requirements spelled out in Table I except that the upper limit for flakiness Index shall be 30%.

**- Fine Aggregate for Type B Seal Coat**

The fine aggregate shall be sand or fine grit and shall consist of clean, hard, durable, uncoated dry particles and shall be free from dust, soft or flaky material, organic matter or other deleterious substances. The aggregate shall pass 1.7 mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cu.m. per 10 sq.m. area.

**Construction Operations****- Preparation of Base**

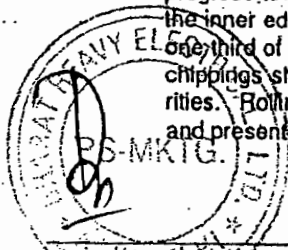
The seal coat shall be applied immediately after the laying of bituminous course which is required to be sealed. Before application of seal coat materials the surface shall be cleaned free of any dust or other extraneous matter.

**- Construction of Type A Seal Coat**

The binder shall be heated in boilers of suitable design, to the temperature appropriate to the grade of bitumen approved by the Engineer and sprayed on the dry surface in a uniform manner preferably with the help of mechanical sprayers. Excessive deposits of binder caused by stopping or starting of the sprayer or through leakage of any other reason shall be suitably corrected before the stone chippings are spread.

Immediately after the application of binder, stone chippings in a dry and clean state, shall be spread uniformly on the surface, preferably by means of a mechanical gritter, otherwise manually so as to cover the surface completely. If necessary, the surface shall be broomed to ensure uniform spread of chippings.

Immediately after the application of the cover material, the entire surface shall be rolled with a 8 - 10 tonne smooth wheeled roller. Rolling shall commence at the edges and progress towards the centre except in superelevated portions where it shall proceed from the inner edges to the outer. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. While rolling is in progress additional chippings shall be spread by hand in whatever quantities required to make up irregularities. Rolling shall continue until all aggregate particles are firmly bedded in the binder and present a uniform closed surface.



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**- Construction of Type B Seal Coat**

Mixers of approved type shall be employed for mixing the aggregates with the bituminous binder.

The binder shall be heated in boilers of suitable design, to the temperature appropriate to the grade of bitumen approved by the Engineer. Also the aggregates shall be dry and suitably heated to a temperature directed by the Engineer before the same are placed in the mixer. Mixing of binder with aggregates to the specified proportions shall be continued till the latter are thoroughly coated with the former.

The mix shall be immediately transported from the mixing plant to the point of use and spread uniformly on the bituminous surface to be sealed.

As soon as sufficient length has been covered with the premixed material, the surface shall be rolled with 8 - 10 tonne smooth wheeled power rollers. Rolling shall be continued till the premixed material completely seals the voids in the bituminous course and a smooth uniform surface is obtained. Wherever use of power roller is not feasible suitable hand roller may be used as per the instructions of the Engineer.

**Opening to Traffic**

In the case of Type B seal coat, traffic may be allowed soon after final rolling when the premixed material has cooled down to the surrounding temperature. However, as regards Type A seal coat traffic shall not be permitted until the following day.

**Repair of Existing Roads**

Pot holes or patches and ruts in existing bitumen road, concrete road and WBM road shall be repaired by removal of all loose material by cutting in rectangular patches and replacing with suitable materials. The repair shall be done as under :

Pot holes, patches and ruts shall be drained of water and out to regular shape with vertical sides, and then be filled either with

- i) coarse aggregate and screenings conforming to the specification for water bound macadam and compacted with rollers or other approved rammer

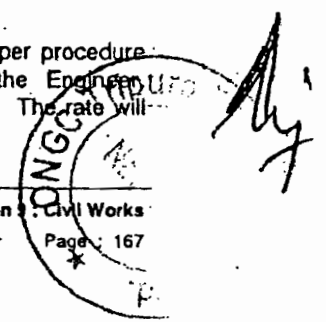
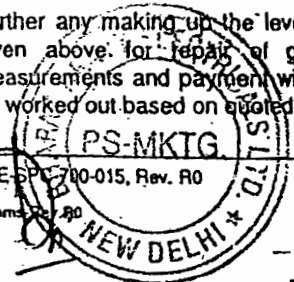
or

- ii) premixed material conforming to the specification for open graded premix carpet and compacted with rollers or other approved means after painting the sides and bottom of the holes with a thin application of bitumen or a combination of both as directed by the Engineer.

Payment for (i) shall be done as per items for water bound macadam and for (ii) as per item for open graded premix carpet. Cutting removal of materials shall be paid under dismantling items.

In case, however it is found that there has been damage to the granular sub-base as well, the area of the damaged surface shall be repaired by removal of all loose materials, out to regular shape with vertical sides and relaid with graded material as per specification of granular sub-base and then surfaced with water bound macadam as per specification for the same.

Further any making up the level of existing soling shall also be done as per procedure given above for repair of granular sub-base and as directed by the Engineer. Measurements and payment will be based on the compacted volume only. The rate will be worked out based on quoted rates for soling of specified thickness.



**9.5.20.4 Quality Control & Tolerance**

The Contractor shall establish and maintain quality control for the various aspects of the work, method, materials and equipment used.

All works performed shall conform to the lines, grades, cross sections and dimensions shown on the drawings or as directed by the Engineer. Permitted tolerances for roadworks are described hereinafter.

**i) Horizontal Alignment :**

Horizontal alignments shall be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the carriageway as constructed shall be correct within a tolerance of ± 25mm therefrom. The corresponding tolerance for edges of the roadway and lower layers of pavement shall be ± 40mm.

**ii) Longitudinal Profile :**

The levels of the subgrade and different pavement courses as constructed, shall not vary from those calculated with reference to the longitudinal and cross-profile of the road shown on the drawings or as directed by the Engineer, beyond tolerances mentioned below :

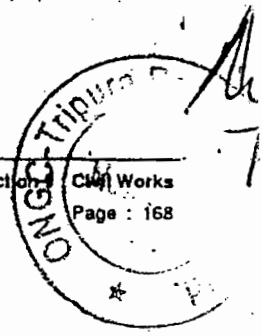
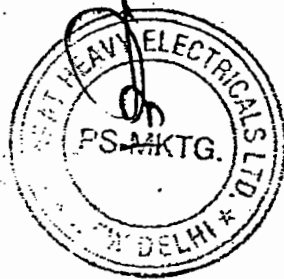
Sub-grade	± 25mm
Sub-base	± 20mm
Base course	± 15mm
Wearing course	± 10mm

Tolerance in wearing course shall not be permitted in conjunction with the positive tolerance for base course if the thickness of the former is thereby reduced by more than 6mm.

**iii) Surface Regularity of Subgrade and Pavement courses :**

The surface regularity of completed sub-bases, base courses and wearing surfaces in the longitudinal and transverse directions shall be within the tolerances indicated in Table V.

The longitudinal profile shall be checked with a 3 metre long straight edge, at the middle of each traffic lane along a line parallel to the centre of the road. The transverse profile shall be checked with a set of three chamber boards at intervals of 10 metres.

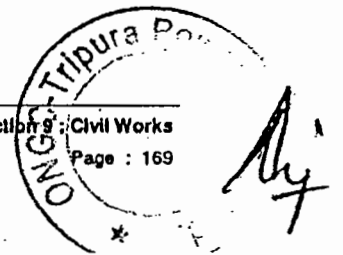
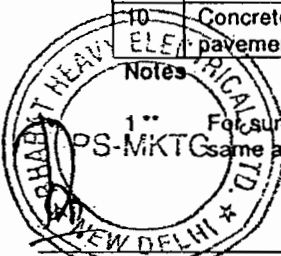


**Table - V**  
**Permitted Tolerances of Surface Regularity for Pavement Courses**

SI No.	Type of construction	Maximum Permissible undulation mm	Longitudinal Profile with 3 metre straight edge				Cross Profile Maximum permissible variation from specified profile under camber template (mm)
			18	12	10	6	
1	Earthen subgrade	25	30	-	-	-	15
2	Granular subbase	15	-	30	-	-	12
3	Water bound macadam with oversize metal (40-90 mm size)	15	-	30	-	-	12
4	Water bound macadam with normal size metal (20-50mm and 40-63 mm size), Bituminuous penetration Macadam	12	-	-	30	-	8
5	Surface dressing ** (two coat over WBM (20-50 mm or 40-63 mm size metal), bituminuous penetration macadam or built-up spray grout	12	-	-	30	-	8
6	Open graded premix carpet, mix seal surfacing	10	-	-	-	30	6
7	Bituminous macadam	10	-	-	-	20***	6
8	Semi-dense carpet	10	-	-	-	20***	6
9	Asphaltic concrete	8	-	-	-	10***	4
10	Concrete pavements	8	-	-	-	10***	4

**Notes**

1\*\* For surface dressing in all other cases, the standards of surface evenness will be the same as those for the surface receiving the surface dressing.



2. ... These are for machine laid surfaces. If laid manually due to unavoidable reasons, tolerance upto 50% above these values in this column may be permitted at the discretion of the Engineer. However, this relaxation does not apply to the values of maximum undulation for longitudinal and cross profiles mentioned in columns 3 and 8 on the table.
3. Surface evenness requirements in respect of both the longitudinal and cross profile should be simultaneously satisfied.

#### 9.5.21 Steel Chimney

##### 9.5.21.1 Scope

This specification covers the specific requirements for design and construction of circular steel chimney including electrical work, lining work/ other associated works.

##### 9.5.21.2 Codes

The design, fabrication and erection of steel chimney shall be strictly as per IS-6533 (Part 1&2) - 1989 except specified otherwise hereunder.

Wherever any reference to IS Codes is made, the same shall be taken as the latest revision at the time of design of work, unless otherwise specified.

Apart from the IS Codes mentioned in the various clauses of this specification, all other relevant IS Codes related to the job under consideration and/or referred to in the above mentioned codes shall be followed where applicable.

##### 9.5.21.3 Design Calculations and Drawings

The contractor shall furnish design calculation, GA drawings and detailed fabrication drawings for the approval of the Engineer-in-Charge.

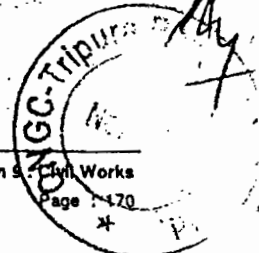
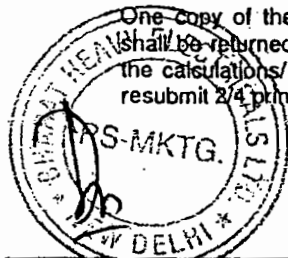
All calculations shall be done in metric units. The calculations shall be supported by all back up documents and references including explanatory sketches and general arrangement drawings.

Where computer program is used, the contractor shall submit a write-up on computer program used and explanation of input and output data for review of Engineer-in-Charge.

All drawings shall be made in metric units showing dimensions in millimeters and levels in meters.

The contractor shall submit 2 sets of calculations/ computer output and 4 sets of drawings to Engineer-in-Charge for review along with 2 sets of schedule of drawings proposed to be prepared. Unchecked and unsigned calculations/computer output and drawings shall not be accepted for review and shall be returned to the contractor.

One copy of the calculation/compute output and drawings submitted by the contractor shall be returned to him and the contractor shall comply with the comments as given on the calculations/ computer output and drawings without any extra cost to the owner and resubmit 2/4 prints of all documents again till final approval.



The contractor shall submit 3 sets of final calculations/ computer output and 6 sets of drawings for distribution by the Engineer-in-Charge after marking 'Approved for Construction' on each drawing. No construction shall proceed at site without 'Approved for Construction' drawings.

It shall be clearly understood by the contractor that review of calculations/computer output and drawings by Engineer-in-Charge shall not absolve the contractor of his responsibility for correctness and soundness of drawings/structure. Any defect/omission observed during construction or till defect liability period of works, shall be rectified by the contractor by carrying out the necessary addition/alteration/modification or reconstruction to the entire satisfaction of the Engineer-in-Charge without any extra cost. The decision of Engineer-in-Charge in this respect shall be final and binding upon the contractor.

After completion of work, contractor shall supply one bound volume of all "as built" final calculations/ computer output and drawings along with one set of reproducible to the owner through Engineer-in-Charge.

#### 9.5.21.4 Loading

##### General

The Chimney shall be designed for all loads including the weight of chimney, accessories, temperature and wind or earthquake. Due consideration shall be given to loadings during the construction/erection phase and accounted for in the design. Design data is given in the Data Sheet enclosed as Annexure-1 to the specification.

##### Dead Load

All permanent loads due to the weight of chimney shell, corbels and lining supported on them, platforms, ladders, flue ducts and other accessories.

##### Imposed Load

Imposed load on service platforms around chimney shall be taken as 300 kg/m<sup>2</sup>. Design live load during construction/erection shall be computed as per actual condition.

Imposed loads from the duct joining the chimney.

##### Wind Load

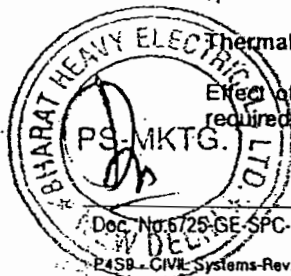
The wind loading shall conform to IS-875, Part III - 1987. Dynamic analysis shall be carried out as per IS-6533 and stability ensured under such condition. If two or more chimneys are spaced at less than 20 times the diameter of bigger chimney at 2/3 of their height or when the chimney is located close to other structure of comparable height, special consideration shall be taken into account for carrying out wind loading analysis due to aerodynamic interference.

##### Earthquake Load

Earthquake forces acting on the chimney and analysis for the same shall be carried out as per IS-1893. The horizontal design seismic coefficient shall be worked out by response spectra method as per IS-1893 with an Importance Factor of 1.5.

##### Thermal Effect

Effect of temperature stresses due to flue gas temperature shall be considered and if required lining shall be provided. If lining is provided the thickness of thermal lining shall



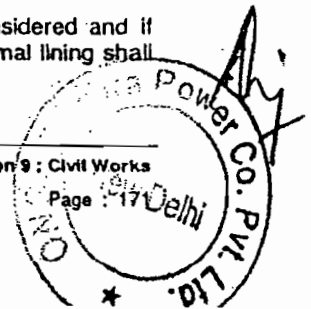
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be so designed that temperature on the inner face of chimney shell at any cross section never exceeds 200° C for steel conforming to IS-226.

#### Local Loads

The effect of following local loads shall also be considered.

- a) Local moment produced by thermal gradient at all thickenings.
- b) Local moment produced by interior brackets.
- c) Local moment due to platform.
- d) Local moment produced by ovaling.
- e) Local buckling of shell.

#### 9.5.21.5 Load Combination

Chimney shall be designed for the most unfavourable load combination during construction, operation and shut down conditions. Various load combinations for calculation of stresses shall be as under.

- a) Dead load + Wind load.
- b) Dead load + Earthquake load.
- c) Dead load + Load due to lining + Imposed load on service platforms + Wind load.
- d) Dead load + Load due to lining + Imposed load on service platform + Earthquake load.

The thickness of lining shall not be assumed to increase the section modulus of the shell nor to resist overturning due to lateral bending action or strutting action from wind/seismic forces for stability checking.

#### 9.5.21.6 Design and Detailing Requirements

The design of chimney shell and other components of chimney shall be done in accordance with the provisions of IS-6533. Permissible stresses shall be as per IS-6533. In case IS-6533 does not cover a particular aspect, provisions of IS-800 shall govern.

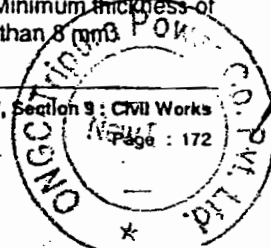
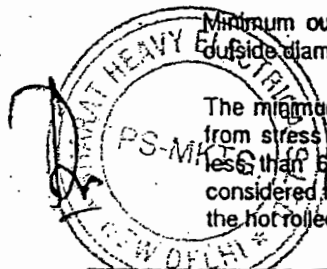
Proportions of the basic dimensions of a self-supporting chimney shall conform to the following:

Minimum height of flare be equal to one-third the height of the chimney.

Minimum outside diameter of unlined chimney shell at top be equal to one-twentieth of the height of cylindrical portion of chimney and for lined chimney it shall be one-twentieth of the height of the cylindrical portion.

Minimum outside diameter of flared chimney shell at base be equal to 1.5 times the outside diameter of chimney shell at top.

The minimum thickness of the chimney shell shall be the calculated thickness obtained from stress and deflection considerations plus the corrosion allowance but shall not be less than 6mm. nor less than 1/500 of the outside diameter of the chimney at the considered height. The corrosion allowance shall be as per IS-6533. Minimum thickness of the hot rolled sections used for external construction shall be not less than 8 mm.



For load combinations involving earthquake the permissible stresses in chimney shell may be exceeded by 33 1/3 % (thirty three and one third percent).

Where large openings/apertures are cut in the shell plate, a structural analysis of the stresses shall be made and compensating material provided, as required, to ensure that the stresses specified in IS Codes are not exceeded.

If the period of natural oscillation for the chimney computed as per IS-6533 exceeds 0.25 sec., the design wind loads shall take into consideration the dynamic effect due to pulsation of thrust caused by wind velocity in addition to the calculated static wind loads. Dynamic effect of wind and resonance shall be checked as per the procedure given in IS 6533 (Part 2) - 1989 and the chimney shall be designed for the same

The stability of the structure as a whole or any part of it shall be investigated to satisfy the following relationship.

$$1.6(r_w + r_m) - 0.9 r_e < 1.8 r_a$$

Where  $r_w$  = Stress produced by wind load.

$r_m$  = Stress produced by any other load which may act to increase the combined stress.

$r_e$  = Stress produced by dead load and any other load which acts at all times and will reduce the combined stress.

$r_a$  = Allowable stress.

The stability of the chimney shall be ensured at all the times by taking into account probable variations in dead load during construction, repair or other similar work.

Suitable stiffeners (12 mm. minimum thickness) shall be provided on either side of each bolt hole of base plate to take care of local bending.

#### 9.5.21.7 Deflection and Tolerance

Permissible deflection at the top of chimney produced by wind load moment taking into account the dynamic factor shall not exceed 1/200 of the unsupported height.

Permissible erection tolerances for chimney shall not exceed the limits specified below. The variation in the eccentricity of the axis of the chimney from the vertical at any level shall not exceed 25 mm. or 1/1000 of the height, whichever is less at that particular section.

#### 9.5.21.8 Thermal Lining

Thermal lining and insulation shall be provided to limit the temperature stresses in the chimney shell and protect the same from abrasive and corrosive action of chimney gases. However, if the flue gas temperature is less than 200° C, lining/insulation may be restricted to the bottom 3.0 m. so as to restrict the outside face temperature to 60° C. In case external insulation is provided the same shall be with 50 mm (min.) mineral wool insulation clad with 1.6 mm. GI sheet. Lining shall preferably be of castable type. The lining shall be supported on supporting rings connected to the chimney shell at about 8 to 10 m. interval. The supporting rings shall be slotted vertically for the full depth to at approximately 900mm. c/c to reduce the effect of temperature stresses.

When the temperature of flue gas is likely to fall below 150° C and moisture is present in the flue gas the chimney shell shall be protected from corrosion for the entire height by provision of 50 mm. (min.) thick cement sand mortar (1:3) applied by gunning. Water

cement ratio shall be between 0.25 to 0.30 by weight. Studs of 3.15 mm. diameter and length equal to half the thickness of guniting should be spot welded to the inside surface of the steel chimney at 500 mm. distance, staggered bothways on to which welded wire fabric of 8 gauge wire of 150 mm. mesh size shall be welded or tied with 16 gauge annealed binding wires. For guniting, water pressure shall be 1.06 kg/cm<sup>2</sup> gauge. Air pressure shall be 2.46 kg/cm<sup>2</sup> or 30 metre length of hose and shall be increased by 0.35kg/cm<sup>2</sup> gauge for every additional 15m. length of hose. The mix shall be shot at right angles to the surface. Immediately after finishing, the surface shall be cured by a sprayed-on coat of an approved curing compound. However the top three (3) metres of the chimney shall be lined with stainless steel under all conditions.

#### 9.5.21.9 Chimney Accessories

##### Inspection/Cleaning door

Suitable door for access near the base shall be provided for the purpose of inspection of the inside of the chimney during construction and for maintenance. The door shall be insulated on the inside face with mineral wool and backed by Asbestos Sheet. Minimum clear access opening shall be 600 mm. x 900 mm. and the sill of the door shall be 300mm. above the finished grade/pavement level outside the chimney. The doors shall be hinged and shall be provided with a locking device. These doors shall be fabricated from mild steel plates and angle sections of thickness not less than 6 mm. and painted as per relevant clauses for Painting in this specification. All construction and details shall be made in such a way so as to ensure no entry of rainwater from outside or leakage of flue gases from inside.

##### Ladder

The chimney shall be provided with a mild steel ladder extending from bottom to top and fabricated in 4.5 to 5.0 metre sections and constructed as follows :

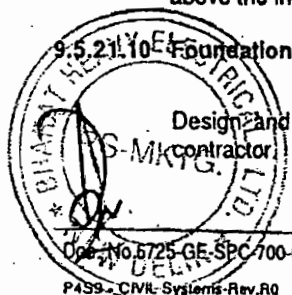
The ladder shall consist of 75 x 75 x 8 angle stringers spaced at 450 mm. clear inside width with 20 mm. dia rungs. The rungs shall be spaced 300 mm. c/c and shall be 250mm. away from the chimney outside surface. Each ladder section shall be bolted together with the next section. The ladder shall be provided with 75 x 10 mm. stays @ 3500 mm. c/c.

The stays shall be bolted/welded to the stringers and welded to the chimney shell. The ladder shall be provided with a safety cage made up of mild steel flats of size 50 x 8 for both verticals and horizontal rings. The cage shall have a minimum diameter of 700 mm. and start from a height of 3000 mm. above ground.

##### Platforms

Steel chimneys shall be provided with chequered plate platforms supported on structural steel sections all around the outer shell for erection and service of warning lamps, earthing, inspection etc., at intervals of about 15 m. The platforms shall be at least 800 mm. wide and provided with tubular handrails of 1 m. height with a toe guard of 125 x 5mm. The top most platform shall be located 1.0 m. below the top of chimney. All platforms shall be provided over the entire periphery of chimney shell.

Sampling Pipe 100 NB sampling pipe along with flange and blind flange shall be provided above the intermediate platform as shown in the drawing.



Design and construction of foundations is also included in the scope of the chimney contractor

- a) Vertical Foundation shall be designed for due to self weight and lining & lateral loads and moments at base plate level due to wind and earthquake loads.
- b) Dimension and details of base plate and anchor bolts.

The bottom of base plate shall be at least 300 mm. above the finished grade level.

#### 9.5.21.11 Construction Requirements

##### Material

##### Structural Steel

The structural steel to be used for steel chimney shall be as per IS-2062 for shell plate unless specified otherwise elsewhere.

##### Welding Electrodes

Welding electrodes shall be of approved manufacturer conforming to IS-814 unless specified otherwise to suit the requirement of shell plate and welding procedure.

##### Base Plate and Holding Down Bolts

The material shall conform to the requirement of IS-432 grade I.

##### Receipt and Storing of Material

All steel parts furnished by supplier shall be checked, sorted out, straightened and arranged by grades and qualities in stores.

All sections shall be free from surface defects such as pitting, cracks, laminations, twists etc. Use of defective materials shall not be permitted and all such defective material shall be removed from the site immediately.

Welding wire and electrodes shall be stored separately by qualities and lots inside a dry and enclosed room, in compliance with IS-9595 and as per instructions given by the Engineer-in-Charge. Electrodes shall be kept perfectly dry to ensure satisfactory operation and weld metal soundness.

##### Fabrication and Erection

All fabrication and erection shall be done in accordance with IS-800, IS-9595 and based on the fabrication drawings adhering strictly to work points and work lines on the same.

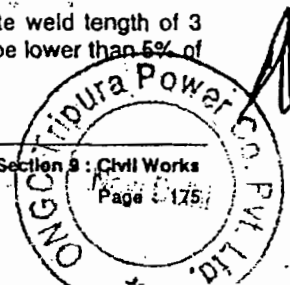
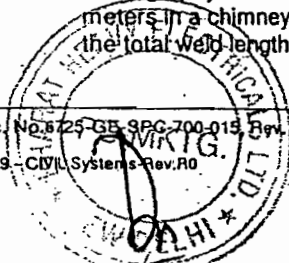
All connections shall be welded connections except for ladders and platforms unless specified otherwise. Welding shall be done as per IS-9595.

The vertical butt weld seam shall be staggered at about 120° between adjacent sections of chimney shell.

Any defective material used shall be replaced by the contractor at his own expense.

Any faulty fabrication pointed out at any stage of work shall be made good by the contractor at his own cost.

Radiography examination shall be carried out to a minimum aggregate weld length of 3 meters in a chimney. However, the weld length radiographed shall not be lower than 5% of the total weld length of the chimney.



At least one spot of 300 mm. length shall be radio-graphed for each thickness produced.

If the random radiography of a weld in any joint reveals unacceptable defects, two further welds in the group represented by the weld shall be radiographed to the same extent. If these further welds show no unacceptable defects, the group of welds represented by the weld shall be accepted. However, the first defective weld shall be repaired. If one of the two further welds show unacceptable defects, each weld in the group shall be radiographed. Unacceptable welds shall be repaired and then radiographed.

#### 9.5.21.12 Painting

All painting work shall be carried out with the best quality of materials and workmanship and in accordance with the best engineering practice and instructions of the Engineer-in-Charge. The compatibility of the paint system shall suit the environment envisaged in and around the plant and confirmed by the paint manufacturer.

##### Chimney Shell

##### Surface preparation

The surface to be painted shall be cleaned by chipping, scraping hammering and wire brushing. On completion of cleaning the detached rust, mill scale and other deleterious material shall be removed by clean rag and/or washed by water or steam and thoroughly dried with compressed air jet if required before application of paint.

##### Internal surface painting

The inside surface shall be given two coats of acid alkali and heat resisting paint conforming to IS:158 over a thinned coat of the same. However if monolithic lining is provided, no painting is required.

##### External surface painting

The top outer surface shall be given two coats of epoxy zinc chromate primer followed by two coats of epoxy high build finish coating of approved quality and shade. Where aviation warning signals are required, top one third of the outer face of the chimney shell shall be painted with two coats of above finish coat of more than one colour (red and white) in horizontal alternate bands of minimum 3 m. width to give a perfect contrast. The bands at extremities shall be of darker colour. Below this height, two coats of aluminium paint to IS:2339 over two coats of zinc chromate primer shall be applied.

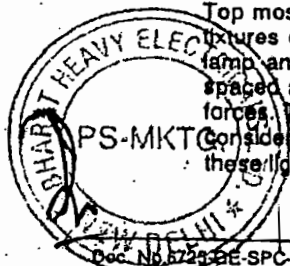
##### Structural Steel Members

All structural steel works shall be sand blasted and given exflux 13, MIO & final painting.

#### 9.5.21.13 Electrical Work

##### Aviation Warning Lighting

Top most external platform shall be provided with three (3) nos. aviation warning lighting fixtures of GEC type ZH752 or equivalent, double obstruction lights, complete with neon lamp and all accessories. These lights shall be erected on the platform railing equally spaced along the periphery and adequately secured to the railing against wind pressure/forces. The lights shall be red in colour having an intensity sufficient to be conspicuous considering the intensity of adjacent lights and general level of illumination against which these lights will be viewed. The intensity of each light shall not be less than 100 cd. These



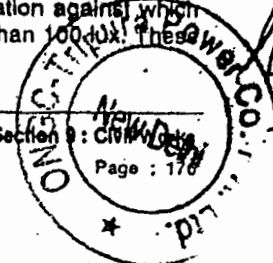
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shall be distributed at intervals of 120° in one horizontal plane. Aviation warning lights shall be distributed on all three phases.

The aviation warning light system design and installation shall conform to the requirements of Civil Aviation Department, Government of India and other statutory regulation.

Temporary aviation obstruction lights shall be provided during construction stage also at the top most point of the obstruction and shall be shifted up as construction progresses. These lights need be installed only if the level of obstruction is greater than 30 m. above grade.

The chimney shall be provided with platforms (walkway) alongwith hand rails etc., at the various levels at which the marker lights are provided to facilitate maintenance of these fixtures. Wiring of alternate fixtures in one horizontal plane shall be from different circuits. The lighting fixtures and junction boxes shall be suitable for use in classified areas as per requirements of IS:5571.

#### Cabling

Cables and wires for feeding aviation warning lights and power outlets shall be supplied and installed by Contractor. Cables from the distribution boards for platform lighting, aviation warning lighting and power sockets shall be routed to junction boxes located at the each platform. For the junction boxes located in the top platform, cables may be looped out from the junction boxes at bottom platform. For each platform wiring for the individual lights and power sockets shall be routed through PVC insulated and sheathed armoured cables from the respective junction boxes.

Wiring to power sockets and aviation warning lights shall be made by PVC insulated, 1100 V grade armoured, aluminium stranded conductors. The armouring shall be made by using single galvanised steel wire having an overall PVC sheathing and complying to IS : 1554. The cables selected shall be in such a way that the voltage drop is limited to 3%.

All cables shall be clamped along the ladder by fixing it suitably so that the cables are thermally insulated from the hot shell of the chimney.

#### Junction Boxes

The junction boxes shall be of Cast Aluminium (LM6) alloy of 16 SWG size. The junction boxes for maintaining the cables shall be provided with necessary cable glands and shall be of vermin proof and weather proof construction.

#### Distribution Boards

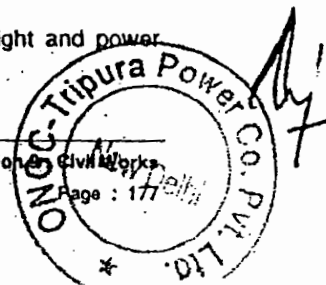
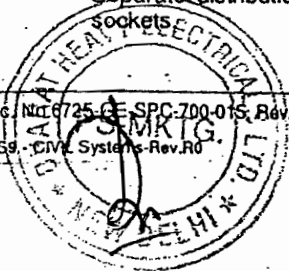
The Contractor shall provide sheet steel distribution board with suitably rated TPN incoming switch fuse unit.

The distribution board shall have the following outgoing circuits :

- Suitable no. of feeders with suitably rated TPN switch fuse units for power sockets at external platform.

The main distribution board shall be located outside the stack. The board shall be painted with one coat of zinc chromate primer (yellow) and two coats of synthetic enamel paint of approved shade. The switches shall be heavy duty type conforming to the requirement of IS : 4064.

Separate distribution board shall be provided for the aviation warning light and power sockets



**Lightning Protection and Earthing System**

Two earth connections shall be provided at the bottom of chimney as per IS requirements to as lightning protection.

Earth pit shall consist of 40 mm. dia, 3000 mm long MS rod electrode in accordance with IS:3043. These earth pits shall be interconnected with 50 x 6 GI flat to be laid at a depth of minimum 600 mm. below grade. At least two pig tails connections to interconnect the local grid with the owner's main grounding grid shall be provided.

**9.5.22 Fencing & Gate****9.5.22.1 Scope**

This specification covers the requirements in respect of materials, workmanship and quality for chainlink/barbedwire fencing fixed on M.S. angle posts or RCC precast posts.

**9.5.22.2 Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder.

- IS:278 Galvanised steel barbed wire for fencing
- IS:1161 Steel tubes for structural purposes
- IS:2062 Steel for general structural steel purposes
- IS:2721 Galvanised steel chainlink fencing

**9.5.22.3 Materials & Installation****Angle Iron Post**

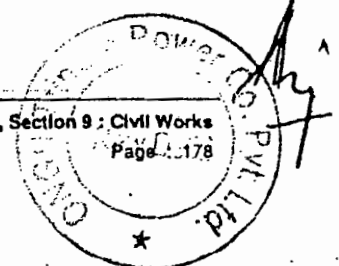
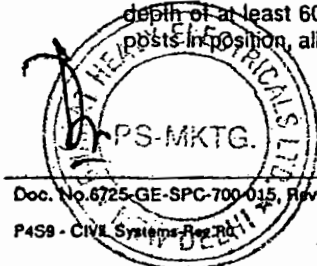
Angle Iron Post shall be rolled angle section conforming to IS:2062 and shall be double dip galvanised.

**Precast Concrete Posts**

Concrete mix shall be M20 as per IS:456. Reinforcement shall be M.S. and/or torsteel bars.

Posts shall be cast in smooth steel forms made to correct dimensions as per drawing and concrete shall be compacted by table vibrators or needle vibrator to give smooth finish. Curing of concrete shall be done by submerging the posts in water tank for minimum 15 days.

Precast posts shall be installed in PCC 13:6 foundation, with a minimum embedment depth of at least 600 mm. Damage to the post shall be avoided during installation of the posts in position, aligning and levelling.



Diagonal post bolted to the vertical posts shall be provided at every eighth bay and on either side of the corner posts. Spacing of the posts shall be not greater than 3 m or as per drawing whichever is less.

All hardwares used shall be of hot-dip galvanised steel.

#### Chain link fence

Chainlink shall conform to IS:2761. It shall be procured in rolls of appropriate length and width and shall consist of 10 G hot dip galvanised steel wires woven in the form of zigzag mesh giving an opening size of 50 mm square.

Chainlink shall be secured to the posts with 6 mm dia GI hooks/rings.

Tension wire shall be provided passing through the mesh at top, centre and bottom of the erected chainlink mesh and shall be of 3 mm dia hot dip galvanised wire and shall be stretched to keep the chainlink in taut position. 25 mm x 6 mm GI flat stretcher bar shall be provided at the end posts to tie the tension wires.

#### Barbed wire fence

Barbed wire shall conform to IS:278

Barbed wire shall be made from hot dipped galvanised wire of 12 G, 2 ply with barbs of 16G spaced at 100 mm.

Barbed wire shall be procured in bundles of standard weights and shall be fully stretched across the posts and secured with G.I. hook bolts and washers.

Spacing of horizontal wires shall not be greater than 225 mm or as specified in the drawing. Diagonal wires shall be provided in each bay between two adjacent posts. No wire shall be left loose or sagging.

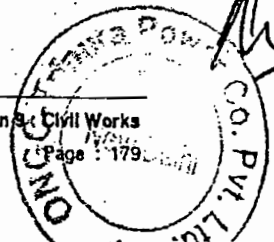
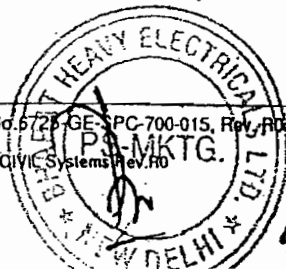
#### Gate

Gate shall be fabricated out of tubular sections conforming to IS:1161 and shall be hot dipped galvanised. Outer frame shall be 65 NB (medium) tube and diagonal 50 NB (medium) tube. 50 mm sq. welded mesh with 4 mm dia GI wire fabric shall be welded to 25 mm x 6 mm thick GI flat which in turn shall be welded to the outer tubular frame. The gate shall be provided with 20 mm wide x 80 mm dia flat M.S. roller at the bottom. The gate frame shall be fixed to GI tubular post or RCC post.

### 9.5.23 Raw Water Reservoir Lining

#### 9.5.23.1 Scope of Specification

This specification covers, but is not limited to lining of Raw Water Reservoir with LDPE film or appropriate liner material to meet statutory requirements and including all other work as described below or as needed to make the Raw Water Reservoir water tight against leakages and percolation of water. The work covers preparation of subgrade including removal of any undesirable material from the soil, providing lining of the film including heat seating the joints etc., protection of the films by laying earth, providing antiweed and / or antitermite treatment, anchoring of the lining etc. and all other work necessary, whether described / specified or not, deemed to be necessary for successful completion of the work in all respects.



In case any defect is found in the lining work, the Contractor shall have to repair the same or redo the whole work without any extra cost to the Owner. It is intended that utmost care should be taken for executing the lining work, so that there is no damage to the lining during execution of the work.

#### 9.5.23.2 General

##### Work to be Provided by the Contractor

Work to be provided unless specified otherwise will 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 plant, transportation, necessary approaches etc. required for completion of work as called by this specification.
- b. Prepare detailed drawing, if needed, for the work, temporary fencing of area for protective measure during the construction stage, provide dewatering arrangement by pumping; if required etc.
- c. Construction, maintenance and removal after completion of magazine of proper capacity as well as design for storage of explosives required for blasting work to be carried out under the scope of this contract.

##### Work to be Provided by Others

No work under this specification will be provided by any agency other than the Contractor.

##### Codes and Standards

All work under this specification, unless specified otherwise shall conform to the latest revision / or replacements of the following or any other Indian Standard specifications and codes and practice or equivalent or superior internationally accepted codes and standards.

IS:1077 Common Burnt Clay Building Bricks - Specification

IS:2508 Specification for Low Density Polyethylene Films

IS:2530 Methods of test for polyethylene moulding materials and polyethylene compounds

IS:14500 Linear low density polyethylene (LLDPE) films

##### Conformity with Designs

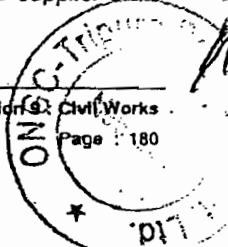
The Contractor is to carry out the work in accordance with the specification and Contractor's drawings.

##### Materials to be Used

All materials required for the work shall conform to applicable codes and standards.

##### General

All materials to be used for the work must meet the specification requirements or the provisions of IS Code. In case of bought-out items, a certificate from the supplier or its deputed agency must be produced along with samples.



## LDPE Films

The black LDPE (Low Density Polyethylene) films heavy duty and wide width, as manufactured and marketed by Indian Petro-Chemicals Corporation Limited (IPCL) made from "INDOTHENE" or approved equivalent as base material shall be used for lining work. INDOTHENE grade shall be 22FA 002 and the basic mechanical properties of above INDOTHENE Grade 22FA 002 are as follows (1 to 3 are properties of Resin and 4 to 7 are properties of the film made out of the resin).

SI No.	Property	Test Method	Unit	Typical Value
1	Melt Flow Index (190°C/2.16 kg)	ASTM D1238	gm / 10 min	0.2
2	Density at 23°C	ASTM D1505	gm / cc	0.920
3	Melting Range	ASTM D2117	°C	108-112
4	Tensile Strength at Break **	ASTM D882	Kg/cm <sup>2</sup>	MD = 260 TD = 240
5	Elongation at Break **	ASTM D882	%	MD = 400 TD = 600
6	Dart Impact strength F-50 **	ASTM D1709/A IS:2508-1984 (at 152.40 cm height)	gm gm	225 100
7	Coefficient of friction	ASTM D1894	-	> 0.5

\*\* Note : Data presented are typical of 40 micron film extruded on 26: 1L/D extruder with BUR = 2:1.

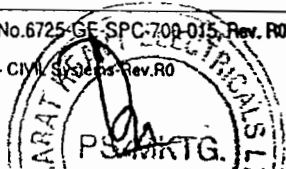
The heavy duty black films of 250 micron thick made from Grade 22FA 002 or approved equivalent, manufactured by IPCL, which are meeting the requirements of IS: 2508-1984, can be used for lining the Raw Water Reservoirs.

The addition of carbon black master batch is to be carried out in certain proportions, so that around 2.5% of carbon black is present in the final product heavy duty black film.

The basic mechanical properties of 250 micron thick film made from INDOTHENE Grade 22FA 002 or approved equivalent which are meeting the requirement of IS: 2508-1984, shall conform to the following:

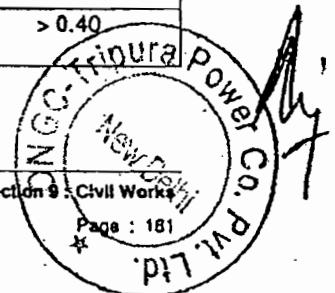
SI No.	Property	Test Method	Unit	Expected value
1	Melt Flow Index	IS 2530	gm / 10 min	0.2
2	Density	IS 2508	gm / cc at 23°C	0.930
3	Carbon Black Content	IS 2530	%	2.5
4	Tolerance on thickness	IS 2508	%	±20
5	Tensile Strength	IS 2508	kg/cm <sup>2</sup>	MD - 140 TD - 110
6	Elongation at Break measured on a 100 micron thick film	IS 2508	%	MD - 200 TD - 400
7	Dart Impact strength for 250 micron	IS 2508	F50 gms	320
8	Kinetic Coefficient of friction	IS 2508	F50 gms	> 0.40

MD = Main direction  
TD = Transverse direction



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Film rolls shall not be allowed to remain exposed to sun during storage. These are to be kept indoors or to be covered with empty gunny bags.

#### Earth / Soil

The excavated soil, selectively taken by Contractor shall be used for covering films and shall be free from pebbles, stones and vegetation. The minimum clay content of this soil shall be 15 percent. No fine sand layer excavated shall be used as a cover over films. If suitable earth is not available at the site, the Contractor shall supply the same from approved locations outside the site.

#### Bricks and Brick Tiles

Bricks and brick tiles shall be of first class (Class Designation 35, Subclass A – IS:1077) quality, well burnt, of uniform size, shape and colour, free from cracks, flaws, or nodules of free lime, and emit clear ringing sound when struck. Fractured surface shall show uniform texture free from grits, holes etc. compressive strengths shall be 35 kg/cm<sup>2</sup> minimum for common bricks. Water absorption after 24 hours immersion shall not exceed 15 percent by weight (or as specified in IS codes) for common bricks. Dimensional tolerance shall not exceed 8 percent of the size shown in drawings for common bricks. All bricks shall have rectangular faces and sharp straight edges. The bricks shall show no efflorescence after soaking in water and drying in shade.

Any brick or consignment of bricks not found to be up to specification shall be rejected outright and shall be removed immediately from the site at the Contractor's expense.

#### 9.5.23.3 Execution

The work shall be strictly executed according to the provisions of this specification, final drawings to be issued, and / or catalogues of the approved manufacturer of LDPE films.

#### Preparation of Subgrade

The subgrade shall be true to level, well compacted and free from undulations. All sharp objects such as rock pieces, boulders, stones, pebbles, roots and weeds shall be cleared to prevent puncturing of the film and holes are to be filled with proper material and compacted. If the bed / sides of excavation for the Raw Water Reservoir is a rock-cut terrain, sharp protrusions shall be levelled off. It is important that the bed, as well as sloping sides and berm of the Raw Water Reservoir, are well compacted.

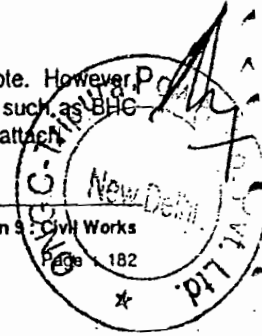
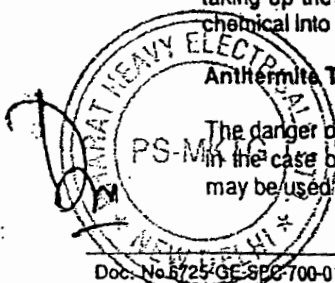
#### Treatment of Weed Infested Areas

For safeguarding LDPE film against the growth of weeds, herbicides (such as Blodex-C, Grammaxene, Fernoxene, or equivalent products) should be mixed with water in accordance with the manufacturer's instructions and this solution should be spread over the earth with a chemical spraying pump on side slopes. No herbicide treatment is required in bed.

The antiweed treatment should be given only after moisture content of the soil is brought below 29 percent. After completion of the spraying of the antiweed chemicals, and before taking up the next activity, a period of 24 hours should be allowed for penetration of the chemical into the soil.

#### Antitermite Treatment

The danger of termites at the bed of the Raw Water Reservoir is rather remote. However, in the case of infested areas, suitable insecticide slurries with insecticides such as BHC may be used over the subgrade and before laying the film to prevent termite attack.



**Ancillary Work**

A toe wall of bricks / precast concrete blocks in 1:4 cement-sand mortar is to be constructed at the foot of the embankment / side slope. The top layer of the toe wall shall be laid only after anchoring the liner used in the lining of the side and bed of the Raw Water Reservoir.

**Laying of LDPE Film****General**

The following precautions / procedures shall be observed during laying operation :

- a. DPE film rolls should not be rough handled or dragged, as the film may become damaged in the process.
- b. Workers should not walk on the film while the lining operation is in progress. In case this is unavoidable, they should walk barefoot.
- c. LDPE films unrolled during lining should be carefully inspected for holes and other defects. The affected area can be rectified by patching.
- d. No sharp edged objects should be plated or rolled over the film.
- e. The LDPE film should not be placed when the temperature is below 32°C (90°F) or above 100°F (38°C).

**Bed Lining****a. Film Laying**

On the level bed of the Raw Water Reservoir, a layer of fine sand of 25 mm thickness is to be spread to provide a cushion for the LDPE film. Sand is to be properly sieved so that *there is no broken stone, brickbat, or any undesirable material, which may damage the film.*

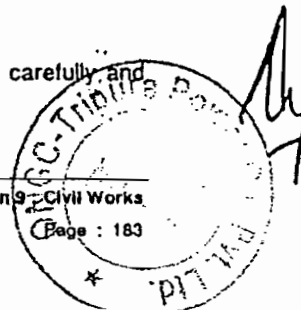
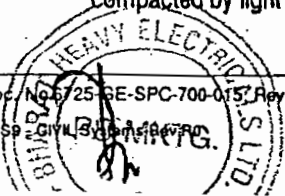
LDPE film of about 6 to 7 meter width and of required lengths is then laid over sand with due care. The film should be spread loosely (with 5 percent allowance in each direction) and distributed evenly along the length and breadth of the film. When the film laying is undertaken at midday, it is recommended that the film be spread only in the area that can be covered with soil or tiles or other materials by the end of the day.

The subsequent and adjacent length of the LDPE film is to be heat sealed for prevention of water loss through the joints.

**b. Bed Cover****i. With Earth**

The cover shall be 300 mm of selected earth. Before placing the earth cover, the LDPE film shall be minutely inspected to ensure that there are no perforations present in the film. Any such perforations should be heat sealed with at least 100 mm patch all around it. A 50 mm thick layer of finely powdered and sieved earth shall be first spread over the laid film.

Subsequent layers (not exceeding 250 mm thick each) shall then be laid carefully, and compacted by light rammer or compactor.



## ii. With Tiles

The bed cover may be provided with tiles in lieu of earth. Brick tiles or bricks or precast concrete blocks shall be laid in 1:5 cement mortar of a minimum 15mm thickness. The joints are left open and finally filled with 1:3 cement sand mortar. The lining shall be cured for minimum 7 days.

## Side Lining

The sides of the Raw Water Reservoir including the berm shown on the drawing, is to be lined with LDPE films or appropriate liner material upto 1000 mm above the natural ground level or as required by the environmental authority.

## a. Film Laying

The film is spread over the subgrade directly. The film shall be laid upto extending 1000 mm or to a height as required by the statutory authorities above the natural ground level of the Raw Water Reservoir. Lining operation in the Raw Water Reservoir sides are to be the same as that for the bed excepting that no sand cushion is provided. One end of the lining is to be anchored in the toe wall and the other end of the lining is to be anchored inside bund.

## b. Side Cover

Brick tiles shall be laid in 1:5 cement mortar of a minimum thickness of 25 mm as shown in the drawing. The joints are left open and finally filled with 1:3 cement-sand mortar, after anchoring of films is over.

The lining shall be cured for minimum 7 days.

Anchoring of LDPE films of appropriate liner material shall be as per relevant clauses above.

## Heat Sealing of LDPE film

The heat sealing shall be done in accordance with manufacturer's recommendations.

## 9.5.23.4 Acceptance Criteria

The installations shall present a neat appearance and shall be checked for water tightness. The following shall be specifically checked :

- LDPE film against mechanical damage, if any
- Laying of LDPE films.
- Method of jointing (heat sealing).
- End sealing or anchoring of LDPE films.
- Laying and jointing of cover tiles.

## 9.5.24 Earthwork for Raw Water Reservoir

## 9.5.24.1 Scope

This specification covers all earthwork necessary for the construction of Raw Water Reservoir as designated on the drawings. It consists of cleaning, grubbing, stripping, and compaction of existing ground surfaces to receive embankment; excavating; undercutting to remove unstable soil areas; compacting bottom and side excavated areas to receive subsequent lining work (wherever specified); filling in layers with excavated soil / or

imported earth for embankment slopes by turfing, leveling and dressing of the surfaces of embankment and filling' providing proper drainage of the excavated pits to suitable sumps; pumping to keep excavated areas dry; disposing of unsuitable and excess excavated spoils including boulders and rock pieces; and incidentals thereof.

#### 9.5.24.2 General

##### Work to be provided by Contractor

The work to be provided 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, earthmoving machinery equipment, tools and plants, transportation, necessary approaches, and other items required to complete the work as called for by this Specification.
- b. To carry out sampling and testing, both insitu as well as in laboratory, and submit to the Engineer progressively, results of soil compaction tests as required by him to assess the degree of compaction in the fill.
- c. Construction, maintenance and removal after completion of magazine of proper capacity as well as design for storage of explosives required for blasting work to be carried out under the scope of this contract.

##### Work to be provided by Others

No work under this specification will be provided by any agency other than the Contractor.

#### 9.5.24.3 Codes and Standards

All work under this specification, unless specified otherwise, shall conform to the latest revision and / or replacements of the following or any other Indian Standard Specifications and Codes and Practice or equivalent or superior internationally accepted codes and standards.

- IS:1200 Method of Measurement of Building and (Part I) Civil Engineering Work : Part I – Earthwork.
- IS:2720 Method of Tests for Soils – Parts II, VII, XXVIII and XXIX.
- IS:3764 Code of Safety for Excavation Work.
- IS:4081 Safety Code for Blasting and Related Drilling operations.
- IS:4701 Code of Practice for Earthwork on Canals.

##### Conformity with Designs

The Contractor is to carry out the works in accordance with Contractor's drawings.

##### Materials to be Used

##### General

All materials required for the work shall conform to applicable codes and standards.



**Borrow Material**

Borrow material required for filling shall be excavated from approved locations and levels. Care shall be exercised that all large clods and broken and no harmful salt, decayed organic matters, roots, grass, and other rubbish are buried in the embankment. Before procuring materials from borrow pits, the top surface shall be stripped off to sufficient depth to remove all perishable material.

**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. Periodic Surveys for checking Lines, Levels and side slope of excavated pits and embankment.
- b. Checking the quality of fill material.
- c. Checking moisture content of the filling.
- d. Checking the degrees of compaction.

**Information regarding Site Condition**

The contour of the ground and other information regarding the nature of the soil, subsoil, and surface water, etc., shown on drawings or otherwise furnished to the contractor shall be taken for guidance only and variation therefrom shall not affect the terms of the Contract. The Contractor must satisfy himself regarding the nature and volume of all work under this item and expected surface and subsurface conditions to be encountered. He must also satisfy himself about the general conditions of site and ascertain the existing land future construction likely to come up during the execution of the contract so that he may evolve a realistic program of execution. If so required, the contractor must satisfy himself of the actual type of soil to be handled by carrying out site visit and necessary tests.

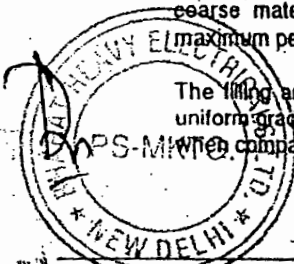
**9.5.24.4 Execution**

Earthwork shall be performed in accordance with the following clauses.

**Filling in Embankment**

The material used for constructing the embankment by earth filling shall be of selected earth, moorum, gravel or a mixture of these, obtained directly from nearby areas where excavation work by the same agency is in progress, from temporary stacks of excavated spoils left by other agencies or from borrow pits from selected areas approved by the Engineer. The cost of fill material / lease charges, if any, and transportation charges shall be borne by the Contractor. The material shall be free from lump and clods, boulders or rock pieces, roots and vegetations, harmful salts and chemicals, organic materials, loose silts, fine sands and expansive clays in order to provide a stable embankment. The size of coarse material in the mixture of earth shall ordinarily not exceed 40 mm, and the maximum percentage of gravel shall be limited to 20%.

The filling and compaction operation should be such as will result in an acceptable and uniform gradation of material to provide for impermeability and stability of the embankment when compacted.



**Stripping and Storing of Top Soil**

The construction of the earthen embankment by filling shall conform to the dimensions, slopes and other details as shown in the drawings. Before commencement of filling for building up the embankment section, the surface area of ground to be occupied, after clearing and grubbing is to be stripped off upto a minimum depth of 150 mm or more as directed by the Engineer in order to remove all perishable material and any soil which may become unstable on saturation or may interfere with development of proper bond between the foundation and embankment.

In localities where most of the available embankment materials are not conducive to plant growth, or when so directed by the Engineer, the topsoil existing over the embankment foundation shall be stripped to specified depths not exceeding 150 mm and stored for covering embankment slopes, cut slopes and other disturbed areas where revegetation is desired.

**Construction Operations****a. Setting Out**

After the site has been cleared the work shall be set out. The limits of embankment shall be marked by fixing batter pegs on both sides at regular intervals as guides before commencing the earthwork. To ensure their safety, it is desirable to fix the pegs about 0.5 metre back from the actual limits of the fill and to paint them in a distinctive colour.

The centreline of the embankment shall be pegged at regular intervals of 25 / 30 m and at all skew / curves. The actual profile of the embankment shall be marked at every third centre-line peg with bamboo and strings. Preferably prototype profiles, developed with bamboo and strings. Preferably prototype profiles, developed with wooden planks need to be fixed at every 200 metres and at intersection points at curves. The profile shall be about 3 metres long.

**b. Original Ground**

In all cases, the original ground shall be completed by rolling as directed by the Engineer, but with a maximum of six passes of 8-10 tonne roller.

Where so directed by the Engineer, any unsuitable material occurring in the embankment foundation shall be removed and replaced by approved materials suitably compacted.

**c. Spreading and Compaction**

The embankment materials shall be spread uniformly over the entire width of the embankment in layers not exceeding 250 mm in thickness. Each layer shall be commenced from the edge farthest from excavation. Top of each layer shall be kept slightly depressed in the centre. Each layer is to be properly compacted before succeeding layer is laid. Compaction shall be carried out with approved mechanised compaction equipment. Usually no manual compaction shall be allowed unless specifically permitted by the Engineer.

Since the degree of compaction depends on the moisture content, a close watch shall be kept on this aspect. Moisture content of the material shall be checked at the source of supply and if found less than specified for compaction, the same shall be made good either at the source or after spreading, the soil in loose thickness for compaction. In the latter case, water shall be sprinkled directly from a hose line or from a truck mounted water tank, and flooding shall not be permitted under any circumstances. If the filling material is found to be wet, it shall be dried, by aeration and exposure to the sun, till the moisture content is acceptable for compaction and moisture control of the soil shall be determined by performing field density tests and other tests as and when directed by the Engineer and

shall conform to the stipulations laid down in IS:4701. Each layer of material shall be thoroughly compacted so that the field dry density is not less than 95% of the maximum laboratory dry density at optimum moisture content obtained in accordance with IS:2720 (Part VII). If road is to be constructed on the embankment the top 0.5 metre portion of embankment below subgrade shall be compacted to field dry density not less than 95% of the maximum laboratory dry density as per IS:2720 (Part VII).

The final side and top surfaces shall be trimmed and levelled to proper profile as shown on the drawing.

#### Protection of Embankment Slopes

The side slopes of the embankment shall be protected against slippage caused by rain cuts, erosion by wind etc. The surface treatment to be adopted will be by turfing / sodding / seeding. Pitching shall be provided on the inner side of the embankment, if required, as per detailed design.

The embankment/bund shall be designed and formed as 4m wide RCC road as per specification unless otherwise specified elsewhere in the specifications or construction drawings.

### 9.5.25 Concrete Roads and Pavements

#### 9.5.25.1 Scope

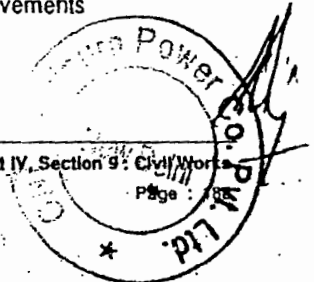
This specification covers the requirement in respect of materials, workmanship and quality for concrete roads and pavements. However, for general requirements, testing etc. the technical specification for plain & reinforced concrete work shall be referred.

#### 9.5.25.2 Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest edition as published by Indian Road Congress and Bureau of Indian Standards shall govern in respect of design, workmanship, quality and properties of materials and method of testing.

Some of the relevant available codes are listed here under :

IS:269	Ordinary and low heat Portland cement
IS:455	Specification for Portland slag cement
IS:456	Code of practice for plain & reinforced concrete
IS:1200	Method of measurement for road work including air field (Part-17) pavements
IS:1489	Specification for Portland pozzolana cement
IS:1838	Specification for performed fillers for expansion joints in concrete pavement and structures.
IS:1834	Specification for hot applied sealing compounds for joints in concrete
IS:6509	Code of practice for installation of joints in concrete pavements
IS:8112	Specification for 43 grade ordinary Portland cement



IRC:15 Standard specification and code of practice for construction of concrete roads

IRC:58 Guidelines for the design of rigid pavements for highways

### 9.5.25.3 Materials

#### Ordinary Portland Cement

This should comply with the requirements of IS:269, IS:455, IS:1489 or IS:8112

#### Aggregates (General)

Aggregates should comply with the requirements of IS:389 - Specification for coarse and fine aggregates from natural sources for the concrete work. In order to make good the concrete for roadwork it is important to avoid crushed aggregates of poor particle shape. Weather rock, and very angular, flaky or splintery aggregates should not be used.

#### Coarse aggregates

This should be furnished in at least two separate sizes with separation at 20 mm when combined material graded from 5 to 38 mm is specified and at 25 mm when combined material graded from 20 to 50 mm is specified. Gap graded single sized coarse aggregate as alternate to the continuously graded may be used particularly where grading of fine aggregate is fine to very fine.

#### Fine aggregate

Fine aggregate shall be natural sand and should comply with IS:383. Bulking due to presence of moisture in the fine aggregate should be accounted for when the volumetric batching is employed.

#### Water

Water is used in mixing or curing of concrete shall be clean and potable quality.

#### Reinforcement

##### Bar mats

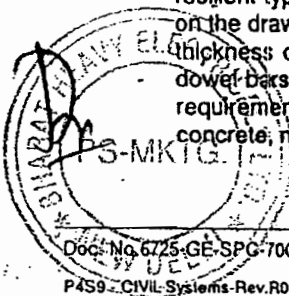
This shall conform to the requirements of IS:432/IS:1786/IS:1139. The bars shall be of the size and spacing shown on the plans. All junctions of longitudinal and transverse bars shall be securely tied or welded together.

##### Load transfer devices

Dowel and tie bars shall be of plain round steel bars conforming to the requirements of IS:432.

##### Expansion joint filler

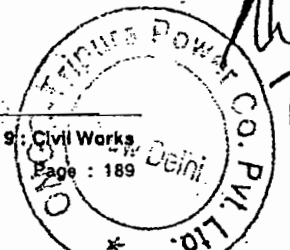
The material for filling the expansion joints shall be of premoulded, non-extruding and resilient type of approved quality. The premoulded joint filler shall be of thickness shown on the drawings or as stated in the bill of quantities. It shall be 25 mm less in depth than the thickness of the slab and of the full width between road forms. Holes to accommodate dowel bars shall be bored or punched out accurately. The joint filler shall comply with the requirements of IS:1838 - Specification for Preformed Fillers for Expansion Joints in concrete; non-extruding and resilient type (bitumen impregnated fibre).



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**Joint sealing compound**

The sealing compound shall comply with the requirements of IS:1834 - Specification for Hot Applied Sealing Compound for joints in concrete.

**Waterproofing under layer**

Waterproofing paper used as under layer be of a brand of approved quality. The paper shall be unrolled with an overlap of not less than 10 cm.

**Forms**

All side forms shall be of mild steel unless use of wooden sections are specifically permitted. The steel forms shall be of M.S. channel sections and their depth equal to the thickness of the pavements.

The sections shall have a length of at least 3 m except on curves where shorter sections may be used. Side shuttering shall be provided at curves as per the drawings or as directed. When set to grade and staked in place, the maximum deviation of the top surface of any section from a straight line shall not exceed 3 mm in vertical plane and 5 mm in horizontal plane. The method of connection between sections shall be such that the joint formed shall be free from movement in any direction. the use of bent, twisted or worn out forms will not be permitted. At least 3 stake pockets for bracing pins or stakes shall be provided for each 3m of form and the bracing and support must be ample to prevent the springing of the forms under pressure of the concrete, or the weight of machinery operating on the forms, contractor shall arrange for sufficient number of forms so that the forms in position are not disturbed within 12 hours of concreting or longer if in the opinion of the Engineer it would be necessary.

**9.5.25.4 Workmanship****Form setting**

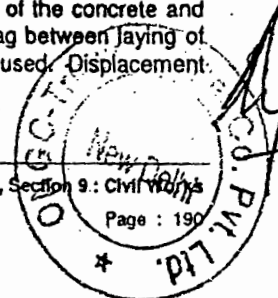
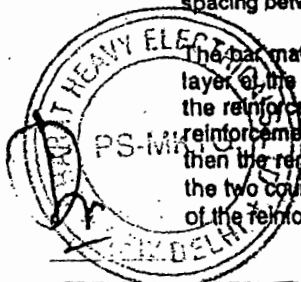
Forms shall be jointed neatly and shall be set with exactness to the required grade and alignment. After the forms are placed and aligned, the earth under the base of the form shall be thoroughly damped in an approved manner. Sufficient rigidity shall be obtained to support the forms in such a position during the entire operation of compaction and finishing. All forms shall be cleaned and oiled each time before they are used.

**Placing of reinforcements**

The overall dimensions of the bar mats shall be such that when properly placed into the work, the extreme longitudinal wires of the mat will be located not less than 50 mm nor more than 100 mm from the edges of the slab. Except for dummy joints, the length of the bar mat shall be such that when properly placed into the work, the reinforcement will be clear of transverse joints by not less than 50 mm and not more than 100 mm when measured from the centre of the joint to the ends of the longitudinal wire of the fabric.

While overlapping the bar mats in either direction, the overlap shall be at least equal to the spacing between the bars in the respective direction.

The bar mats shall be placed in position as shown on the drawings. For placing the top layer of the reinforcement, the first stage of concreting shall be brought up to the level of the reinforcement and lightly compacted by a screed vibrator to obtain uniform level. The reinforcement bar mats shall then be placed on the compacted layer of the concrete and then the remaining depth shall be filled in with concrete. The time lag between laying of the two courses shall not exceed the initial setting time of the cement used. Displacement of the reinforcement during concreting operation shall be prevented.



**Fixing dowel bars.**

The dowel bars in expansion joints and transverse construction joints shall be placed and supported in such a manner that they will be truly parallel with the gradient and the centreline to the pavement, and they shall remain in position during the placement and compaction of the concrete. They shall be placed at the mid depth of the slab and the drawings. Half length of the dowel bars shall be painted with one coat of hot bitumen of approved make or equivalent as shown on the drawings or as directed by the Engineer.

**Fixing tie bars**

Tie bars in longitudinal joints shall be placed approximately the mid depth of the slab and shall be securely held in the slabs on both sides of the joints.

**Transporting and placing of concrete**

The concrete shall be mixed in quantities required for immediate use and shall be deposited in position to the required depth and width of the pavement, sections, in successive batches and in continuous operation without the use of intermediate forms or bulk continuous between joints. The spreading shall be as uniform as possible to avoid re-handling of concrete.

**Compaction and finishing**

The surface of the pavement shall be compacted either by means of power driven finishing or by a vibration screed. For areas where the width of the slab is very small, hand compaction and finishing may be adopted. Immediately after the tamping or screeding has been completed and before the concrete has hardened the surface shall be inspected for irregularities with a profile checking template and any needed corrections made by adding or removing of concrete followed by further compaction and finishing.

**Floating**

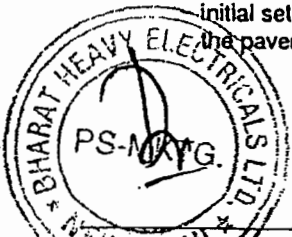
As soon as practicable after the concrete has been struck off and a compacted it shall be further smoothed and compacted by means of longitudinal float operation from a foot bridge.

**Straight edging**

After the longitudinal float has been completed and excess water has been disappeared but while the concrete is still plastic, the slab surface shall be tested for trueness with a 3 metre straight edge swung from handles 1 metre longer than one half width of the slab. Any depressions found shall be filled immediately with freshly mixed concrete, struck, compacted and refinished. High areas shall be cut down and refinished. No extra payment shall be made for the removal of the rejected concrete and for laying of the fresh concrete. Unless otherwise specified, and for laying of the pavement surface shall be obtained by belting or brooming or by a combination of both as directed by the Engineer.

**Edging**

After belting and / or brooming has been completed, but before the concrete has taken its initial set, the edges of the slab shall be carefully finished with a edger of 6 mm radius and the pavement edge shall be left smooth and true to line.



## 9.5.25.5 Joints

## Expansion Joints

Expansion joints shall be formed at the intervals shown on the drawing at right angles of the longitudinal axis of the pavement. The width of the joint shall be as shown on the drawing and shall be straight, truly vertical and shall extend from the bottom of the slab. The expansion joint shall be filled with an approved pre-moulded joint filler, which shall extend from the bottom of the slab to 25 mm below the finished surface of the concrete. A timber or metal cap shall be fitted temporarily on the top of the joint filler and the top of this cap shall be flush with the finished surface. Care shall be taken that filler and the cap are set accurately in position and are maintained in position during placing and compaction of concrete. After the pavement has been struck off and finished the metal cap shall be removed. Under no circumstances shall any concrete be left above the expansion joint material or across the joint at any point. After about 15 days of concreting the cavity on the top of the joint filler shall be carefully cleaned of all loose materials and sealed with an approved joint sealing compound. The sealing shall not be done until the concrete is quite dry. The sealer and any primer required shall be applied strictly in accordance with manufacturer's instructions. The joints shall be sealed flush with the surface of the concrete. The end of the sliding half of the dowel bar shall be provided with a PVC or G.I. sheets cap at least 75 mm long and minimum 25 mm length of this cap shall be filled with cotton waste dipped in hot bitumen as shown on the drawings.

## Longitudinal and transverse construction joints

These shall be of top chamfered and sealed type and shall be formed by placing the concrete against the face of the slabs concrete earlier. The face of the old concrete slabs shall be painted with bitumen before placing of fresh concrete.

Tie bars shall be used at construction joints and shall be of the dimensions and at spacings as shown on the drawings.

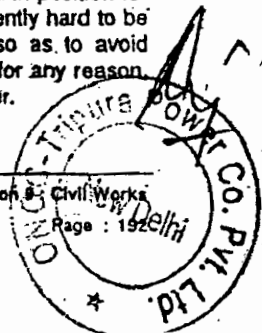
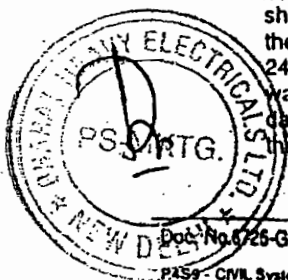
## 9.5.25.6 Curing

Immediately after finishing operations have been completed the entire surface of the newly laid concrete shall be covered against rapid drying and cured in accordance with the following methods.

Failure to provide sufficient cover material of whatever kind required or inadequate supplies of water to take care of both curing as well as other requirements shall be adequate cause for immediate suspension of concreting.

## Initial curing

Immediately after completion of finishing operations, the surface of the pavement shall be entirely covered with wetting burlap, cotton or jute mats. The mats used shall be of such length (or width) that as laid they will extend at least 450 mm beyond the edges of the slab. The mats shall be placed so that the entire surface and both the edges of the slab are completely covered. The covering shall be placed as soon as the concrete has set sufficiently to prevent marring of the surface. Prior to being placed, the mats shall be thoroughly saturated with water and shall be placed with the wettest side down. The mats shall be so placed and weighed down as to cause them to remain in intimate contact with the surface covered, and the covering shall be maintained fully wetted and in position for 24 hours after the concrete has been placed or until the concrete is sufficiently hard to be walked on without suffering damage. Water shall be gently sprayed so as to avoid damage to the fresh concrete. If it becomes necessary to remove a mat for any reason the concrete slab shall not be exposed for a period of more than half an hour.



Worn burlap or burlap with holes will not be permitted. Burlap reclaimed from previous use other than curing concrete shall be thoroughly washed prior to use for curing purposes. If burlap is furnished in strips, the strip shall be laid overlap at least 150 mm. Burlap shall be placed from suitable bridges. Walking on freshly laid concrete to facilitate placing burlap is not permitted.

#### Final curing

Upon removal of the burlap the slab shall be thoroughly wetted and then finally cured as under :

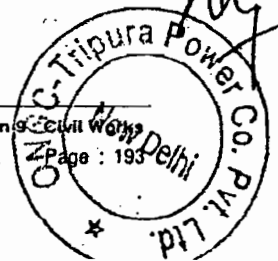
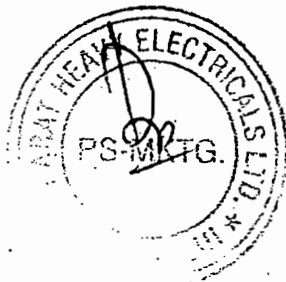
"Exposed edges of the slab shall be banked with a substantial berm of earth. Upon the slab shall then be laid a system of transverse and longitudinal dykes of clay about 50 mm high immediately covered with a blanket of sandy soil free from stones to prevent the drying up and cracking of clay. The rest of the slab shall then be covered with sufficient sandy soil so as to produce a blanket of earth not less than 37 mm depth after wetting. The earth covered shall be thoroughly wetted while it is being placed on the surface and against the sides of the slab and kept thoroughly saturated with water for 14 days and thoroughly wetted down during the morning of the 15<sup>th</sup> day and shall thereafter remain in place until the concrete has attained the required strength and permission is given, the covering shall be removed and the pavement cleaned and swept. If the earth covering becomes displaced during the curing period, it shall be replaced to the original depth and shall be re-saturated".

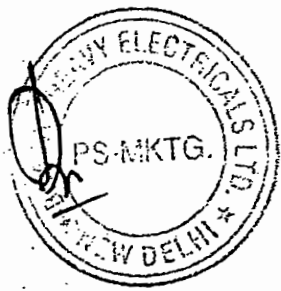
#### Removing of Forms

Forms shall not be removed from freshly placed concrete until it has set at least 12 hours. They shall be carefully removed and in such a manner that no damage will be done to the edges of the pavement. After the forms have been removed, the ends of all joints shall be cleaned and any honeycombed areas painted up with 1:2 mortar, after which the sides of the slabs shall be covered with earth to the level of the top of the slab. All ditches and drains shall be so placed as to provide effective drainage.

#### Opening to Traffic

Traffic shall be excluded from the newly constructed pavement for a period of 28 days where ordinary portland cement is used. Before the pavement is opened to traffic it shall be cleaned and the joints shall be filled and trimmed or topped out as required. The joint or line of separation between adjacent strips or slabs of concrete, when the pavement is constructed in lanes or strips, shall be cleaned and filled with bituminous material as directed.







**TRANSMISSION BUSINESS GROUP  
(Subcontracts Management)**

Doc. No. TBSM/Std-Spec/Cov-Str/01

Rev. 01

**SPECIFICATION FOR COVERED STORE FOR SWITCHYARD**

1. The covered store shall be constructed of adequately designed steel columns and tubular trusses (span 10m) placed at an interval of 5.00m centre to centre with suitable purlins and runners provided to support the roofing & cladding. The length of the store shall be 20.00/15.00/10.00m. depending on the requirement as indicated in the BOQ.
2. The roofing and side cladding shall be of GS corrugated sheets (0.8mm thick) fixed to purlins & runners with suitable polymer/GI coated J or L hooks, bolts and nuts 8 mm diameter with bitumen and G.I. Limpet washers or with G.I limpet washers filled with white lead and including a coat of approved steel primer and two coats of approved paint on overlapping of sheets complete (up to a pitch of 60 degrees).. The roof shall be made with proper arrangements to prevent water leakage.
3. The bottom of the truss shall be 4.50m. above FFL (Finished floor level).
4. The steel columns shall be supported on adequately designed concrete pedestals & footings. The following minimum requirements shall be ensured..
  - Depth of footing below existing ground level = 1.00m
  - Size of footing = 1.50m X 1.50m
  - Depth of footing = 0.30m
  - Reinforcement in footing = 12dia @ 150 c/c bothways, top & bottom.
  - Size of pedestal = 0.50m X 0.50m
  - Reinforcement in pedestal ó Longitudinal = 8 Nos 16dia  
- Ties = 8dia @ 200c/c
5. 230mm thick brick walls in cement mortar 1:6 shall be provided all along the periphery and shall be 1.50m above the FFL. This shall rest on suitable brick masonry foundation which shall extend to minimum 500mm below the FFL. 12/15mm plaster in cement mortar 1:6 shall be provided on the walls which shall be finally painted with 3 coats of colourwash.
6. The floor of the store shall be made with 100mm thick PCC 1:4:8 neatly finished and laid over 150mm thick boulder soling with interstices filled with suitable material. The area below this upto the natural ground level shall be filled with well compacted earth.
7. The store shall be provided with a 4.00m wide X 4.50m high lockable & painted rolling shutter with all accessories, as required. In addition, painted steel ventilators of size 1.20m wide X 0.50m high shall be provided between each span and along both longitudinal

directions and at a height of 4 Mts above FFL. In front of the rolling shutter, suitable ramp shall be provided for material entry.

8. Adequate no. of fire extinguishers (min. 4 nos. CO<sub>2</sub> and 2 nos. foam type) and sand & water buckets shall be provided in the store area.
9. Adequate illumination arrangements shall be made inside the store - comprising of min. of 4 tube light fittings and a 15Amp. power socket and suitable switchboard at the entrance to the stores. The switch board shall also serve as the controlling point for illumination of open store yard. Providing of incomer cable and giving supply to the switchboard is NOT in the scope of store construction.
10. All materials shall conform to IS and shall be procured from approved sources & reputed manufacturer(s). The execution of work shall be as per latest CPWD/IS specifications & directions of Engineer-in-Charge.



**TRANSMISSION BUSINESS GROUP  
(Subcontracts Management)**

Doc. No. TBSM/Std-Spec/Open-Str/02

Rev. 01

**SPECIFICATION FOR OPEN STORE FOR SWITCHYARD**

1. The area of the open store shall be as indicated in the BOQ.
2. The area identified for the open store shall be enclosed with barbed wire fencing-1.8 M high above ground level with 8 strands of horizontal and two diagonal barbed wires (between 2 posts). The posts shall be of medium M.S tubes of 50mm dia or angle 50x50x6 and shall be spaced 3.0m centre to centre. Inclined post supports shall be provided at all corners and at every 10<sup>th</sup> post. All posts shall be embedded at least 0.4m in PCC 1:2:4 block of size 0.40x0.40x0.6m. 75mm thick PCC 1:4:8 shall be provided below concrete block.
3. One 5m wide X 1.8m high (2 leaf) gate suitable for truck/ trailer entry and one 1m wide X 1.8m high wicket gate suitable for personnel entry shall be provided. The gate shall be of pipe framework (having suitable stiffness) with welded mesh suitably fixed on it.. The gate shall be provided with suitable locking arrangement.
4. The area of the open store shall be raised minimum 150mm above the surrounding ground level with compacted earth. Over this, flat brick soling or some other suitable alternative material of minimum thickness 75mm shall be provided.
5. One central road 3.75 mts. wide located centrally along the long axis of the stores shall be constructed with 150mm compacted thickness boulder soling interstices filled with moorum and adequately rolled and compacted. The top of the road shall be 150mm above the yard soling level. The total area of the road shall be maximum 15% of the area of the open store.
6. One security cabin of size 2.0m x 2.0m shall be provided inside the fence adjacent to the gate. Four nos. of sand and water buckets on suitable stand shall be provided adjacent to the cabin.
7. The area shall be adequately illuminated with min. 4 nos. of halogen lamps at the four corners of the stores and 1 tube light in the security cabin. The scope includes cabling from the main switch in the covered stores and interconnected cabling. Where the scope includes only the open store, the main switch shall be provided inside the security cabin
8. All materials shall conform to IS and shall be procured from approved sources & reputed manufacturer(s). The execution of work shall be as per latest CPWD/IS specifications & directions of Engineer-in-Charge.

**FORMAT FOR NO DEVIATION CERTIFICATE**  
**(To be submitted in the bidder's letter head)**

BHARAT HEAVY ELECTRICALS LIMITED,  
 Power Sector - Eastern Region,  
 Plot no 9/1, DJ Block, Sector – II, Salt Lake City,  
Kolkata – 700 091

Sub	No Deviation Certificate.	
Job	Civil, structural, architectural work including foundations/ superstructure of various plant equipments/ systems/ facilities, non-plant buildings/ facilities, misc civil work, switch yard civil work etc of unit # 1 & 2 of 726.6 MW Gas based CCPP at Palatana, Udaipur, Tripura.	
Ref	1.0	Tender no PSER:SCT:PAL-C987:09.
	2.0	BHEL's NIT, vide reference no PSER:SCT:PAL-C987:1718, dated 23-03-09.
	3.0	BHEL's TCN-01, vide reference no PSER:SCT:PAL-C987:TCN-01, dated 08-04-09.
	4.0	BHEL's TCN-02, vide reference no PSER:SCT:PAL-C987:TCN-02, dated 15-04-09.
	5.0	BHEL's TCN-03, vide reference no PSER:SCT:PAL-C987:TCN-03, dated 18-04-09.
	6.0	BHEL's TCN-04, vide reference no PSER:SCT:PAL-C987:TCN-04, dated 23-04-09.
	7.0	BHEL's TCN-05, vide reference no PSER:SCT:PAL-C987:TCN-05, dated 24-04-09.
	8.0	BHEL's TCN-04, vide reference no PSER:SCT:PAL-C987:TCN-06, dated 28-04-09.
	9.0	All other pertinent issues till date.

Dear Sirs,

With reference to above, this is to confirm that as per tender conditions, we have visited site before submission of our offer and noted the job content & site conditions etc. We also confirm that we have not changed/ modified the tender documents as appeared in the website/ issued by you and in case of such observance at any stage, it shall be treated as null and void.

We hereby confirm that we have not taken any deviation from tender clauses together with other references as enumerated in the above referred NIT and convey our unqualified acceptance to all terms & conditions, unqualified compliance to technical specification, compliance to Integrity Pact and acceptance to reverse auctioning process. We also confirm that we have submitted the Integrity Pact duly signed by the authorized signatory along with techno commercial bid.

In the event of observance of any deviation in any part of our offer at a later date whether implicit or explicit, the deviations shall stand null & void.

We confirm to have submitted offer in accordance with tender instructions and as per aforesaid references.

Thanking you,

Yours faithfully,

(Signature, date & seal of authorized  
representative of the bidder)

<b>TENDER NO</b>	<b>PSER:SCT:PAL-C987:09</b>	
<b>VOLUME</b>	<b>IIIA, REV-2</b>	<b>PRICE SCHEDULE, (ABSOLUTE VALUE)</b>

<b>JOB</b>	<b>CIVIL, STRUCTURAL, ARCHITECTURAL WORK INCLUDING FOUNDATION/ SUPERSTRUCTURE OF VARIOUS PLANT EQUIPMENTS/ SYSTEMS/ FACILITIES, NON-PLANT BUILDINGS/ FACILITIES, MISC CIVIL WORK, SWITCH YARD CIVIL WORK ETC</b>
<b>CAPACITY</b>	<b>UNIT # 1 &amp; 2 OF 726.6 MW GAS BASED CCPP.</b>
<b>PROJECT</b>	<b>PALATANA, UDAIPUR, TRIPURA.</b>

**BHARAT HEAVY ELECTRICALS LIMITED**  
**(A Govt Of India Undertaking)**  
**POWER SECTOR – EASTERN REGION**  
**PLOT – DJ 9/1, SECTOR II, SALT LAKE**  
**KOLKATA – 700 091**